Programmatic Biological Assessment

WORKING DRAFT

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BA Acronym List

µg/L	micrograms per liter
µs	microsiemens
AC	activated carbon
ACM	Active Channel Margin
AMEC	AMEC Environment & Infrastructure, Inc.
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BA	biological assessment
BaP	benzo(a)pyrene
BEHP	bis-2(ethylhexyl)phthalate
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
BMP	best management practice
BO	biological opinion
BRT	Biological Review Team
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	chemical of concern
CRD	Columbia River Datum
CWA	Clean Water Act
DC	direct current
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DDx	DDD, DDE, and DDT
DEQ	Oregon Department of Environmental Quality
DO	dissolved oxygen

DPS	distinct population segment
DSL	Oregon Department of State Lands
EFH	essential fish habitat
EMNR	enhanced monitored natural recovery
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCV	final chronic value
FMD	future maintenance dredge
FMO	forage, migration, and overwintering
FS	Feasibility Study
GAC	granular activated carbon
GPS	global positioning system
HEA	habitat equivalency analysis
HQ	hazard quotient
IC	institutional control
ITRC	Interstate Technology & Regulatory Council
kg	kilograms
km	kilometers
Kow	partitioning coefficient
LCR	Lower Columbia River
LWD	large woody debris
LWG	Lower Willamette Group
MCL	maximum contaminant level
MLLW	mean lower low water
m	meters
mg/L	milligrams per liter
mm	millimeters
MNR	monitored natural recovery
MOU	Memorandum of Understanding
NAPL	non-aqueous phase liquid
NAVD 88	North American Vertical Datum of 1988

NCP	National Contingency Plan
NDPS	northern distinct population segment
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTU	nephelometric turbidity unit
NWF	National Wildlife Federation
ODFW	Oregon Department of Fish and Wildlife
OHA	Oregon Health Authority
OHW	ordinary high water
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	primary constituent element
PeCDD	1,2,3,7,8-Pentachlorodibenzo-p-dioxin
PeCDF	2,3,4,7,8-Pentachlorodibenzofuran
PFMC	Pacific Fisheries Management Council
PIT	passive integrated transponder
PNNL	Pacific Northwest National Laboratory
POTW	publicly owned treatment works
ppb	parts per billion
ppm	parts per million
PRG	preliminary remediation goal
PTW	principal threat waste
RAL	remedial action level
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RHV	relative habitat value
RI	Remedial Investigation
RKM	river kilometer
RM	river mile
RNA	regulated navigation area

ROD	Record of Decision
Site	Portland Harbor Superfund Site
SDPS	southern distinct population segment
SFA	Sustainable Fisheries Act
SMA	sediment management area
SOP	standard operating procedure
SPCC	Spill Prevention, Containment and Countermeasure
SWAC	surface area weighted average concentrations
TCDD	2,3,7,8- Tetrachlorodibenzo-p-dioxin
TEQ	toxic equivalent
TBT	tributyltin
TMDL	total maximum daily load
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
TZW	transition zone water
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington State Department of Ecology
WQMCCP	Water Quality Monitoring and Compliance Conditions Plan
WSDOT	Washington State Department of Transportation

1.0 INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

The Portland Harbor Superfund Site (Site) was evaluated and proposed for inclusion on the National Priorities List (NPL) pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and formally listed as a Superfund Site in December 2000. The lead agency for this Site is the U.S. Environmental Protection Agency (EPA).

Several investigations of the Site have been conducted by Respondents to the Administrative Settlement Agreement and Administrative Order on Consent (AOC), Docket No. CERCLA-10-2001-0240, (aka, the Lower Willamette Group [LWG]) for the Portland Harbor Remedial Investigation (RI) and Feasibility Study (FS) (EPA 2001, 2003a, 2006a). As part of the RI, Baseline Ecological and Human Health Risk Assessments were completed (Windward 2011; Kennedy Jenks 2013, respectively).

Oversight of LWG's Portland Harbor RI/FS is being provided by EPA with support from Oregon Department of Environmental Quality (DEQ). EPA has entered into a Memorandum of Understanding (MOU) with DEQ, six federally recognized tribes, two other federal agencies, and one other state agency, who have all participated in providing support in the development of the RI/FS.

The Site extends from river mile (RM) 1.9 to 11.8 as shown in **Figure 1-1**. Some riverbank areas with known contamination are also included as part of the Site under the proposed action (**Figure 1-2a-f**). Currently, DEQ is investigating or directing source control work at over 90 upland sites in Portland Harbor and evaluating investigation and remediation information at more than 80 other upland sites in the vicinity (DEQ 2014). Additionally, DEQ is working with the City of Portland under an Intergovernmental Agreement to identify and control upland sources draining to the Study Area through 39 city outfalls, and with the Oregon Department of Transportation on controlling sources in highway and bridge runoff drained to the Site (City of Portland 2012).

While the harbor area is extensively industrialized, it occurs within a region characterized by a mix of commercial, residential, recreational, and agricultural uses. Land uses along the Lower Willamette River include marine terminals, manufacturing, and other commercial operations as well as public facilities, parks, and open spaces. As discussed further in **Section 2** of this document, EPA evaluated several remedial alternatives and will develop a proposed plan for the Site. The terms Site, harbor-wide, and site-wide used in this evaluation generally refer to the river sediments, pore water, and surface water within this reach of the Lower Willamette River and not to the upland portions of the Portland Harbor Superfund Site.

The purpose of the proposed action is to reduce potential risks from contaminated sediments and surface water to acceptable levels consistent with the remedial action objectives (RAOs) established for the Site in the FS.

The need for the proposed action is based on the presence of chemicals of concern (COCs) in sediments, groundwater, surface water, and riverbanks in the Portland Harbor Superfund Site, as described in detail in the RI and further summarized in the FS. Most of the sediment contamination at the Site is associated with known or suspected historical sources and practices. Ongoing sources of contamination include contaminated groundwater plumes, riverbank soils, stormwater and upstream surface water. Primary COCs in sediments at the Site include polychlorinated biphenyls (PCBs); dioxins/furans; pesticides, including dichlorodiphenyltrichloroethane (DDT) (with dichlorodiphenyldichloroethylene [DDE] and dichlorodiphenyldichloroethane [DDD], collectively DDx), chlordane, aldrin, and dieldrin; polycyclic aromatic hydrocarbons (PAHs); metals; and many others. Persistent contaminants (particularly PCBs and dioxin/furans) from sediments and surface water bioaccumulate in progressively higher trophic levels within the food chain.

The baseline human health risk assessment (BHHRA) developed as part of the RI presents an analysis of the potential for effects associated with both current and potential future human exposures to COCs at the Site. Potential exposure to contaminants found in environmental media and biota was evaluated for various occupational and recreational uses of the river as well as recreational, subsistence, and traditional and ceremonial tribal consumption of fish caught within the Site. Additionally, because of the persistent and bioaccumulative nature of many of the contaminants found in sediment, infant consumption of human breast milk was also quantitatively evaluated.

Based on the BHHRA, the Site poses unacceptable cancer risks and noncancer hazards from the consumption of fish or shellfish. PCBs are the primary contributor to risk from fish consumption harbor-wide. When evaluated on a river mile scale, dioxins/furans are a secondary contributor to the overall risk and hazard estimates. PCBs are the primary contributors to the noncancer hazard to nursing infants, primarily because of the bioaccumulative properties of PCBs and the susceptibility of infants to the developmental effects associated with exposure to PCBs.

The baseline ecological risk assessment (BERA) presents an evaluation of risks to aquatic and aquatic-dependent species within the Site. The BERA found that 93 contaminants (as individual contaminants, sums, or totals) pose potentially unacceptable ecological risks. The list of contaminants posing potentially unacceptable risks can be condensed if individual PCB, DDx and PAH compounds or groups are condensed into three comprehensive groups: total PCBs, total DDx, and total PAHs. Doing so reduces the number of contaminants posing potentially unacceptable risks to 66.

The contaminants identified as posing potentially unacceptable ecological risk are (in decreasing frequency of occurrence) total PCBs, copper, total DDx, lead, tributyltin (TBT), zinc, total toxic equivalent (TEQ), PCB TEQ, benzo(a)pyrene, cadmium, 4,4′-DDT, dioxin/furan TEQ, bis(2-ethylhexyl) phthalate, naphthalene, and benzo(a)anthracene.

The most ecologically significant COCs are PCBs, PAHs, dioxins and furans (as TEQ), and DDT and its metabolites. Total PAHs, total PCBs, total DDx have the greatest areal extent of unacceptable ecological risk. Of these, PAH and DDx risks are largely limited to benthic invertebrates and other sediment-associated receptors. PCBs tend to pose their largest ecological risks to mammals and birds.

RAOs were established for the Site in the FS. RAOs consist of media-specific goals for protecting human health and the environment. RAOs provide a general description of what the cleanup is expected to accomplish and help to focus alternative development and evaluation.

Human Health

- RAO 1 – Sediments: Reduce cancer and noncancer risks to people from incidental ingestion of and dermal contact with COCs in sediments and beaches to exposure levels that are acceptable for fishing, occupational, recreational, and ceremonial uses.

- RAO 2 – Biota: Reduce cancer and noncancer risks to acceptable exposure levels (direct and indirect) for human consumption of COCs in fish and shellfish.

- RAO 3 – Surface Water: Reduce cancer and noncancer risks to people from direct contact (ingestion, inhalation, and dermal contact) with COCs in surface water to exposure levels that are acceptable for fishing, occupational, recreational, and potential drinking water supply.

- RAO 4 – Groundwater: Reduce migration of COCs in groundwater to sediment and surface water such that levels are acceptable in sediment and surface water for human exposure.

Ecological

- RAO 5 – Sediments: Reduce risk to ecological receptors from ingestion of and direct contact with COCs in sediment to acceptable exposure levels.

- RAO 6 – Biota (Predators): Reduce risks to ecological receptors that consume COCs in prey to acceptable exposure levels.

- RAO 7 – Surface Water: Reduce risks to ecological receptors from ingestion of and direct contact with COCs in surface water to acceptable exposure levels.

- RAO 8 – Groundwater: Reduce migration of COCs in groundwater to sediment and surface water such that levels are acceptable in sediment and surface water for ecological exposure.

- RAO 9 – Riverbanks: Reduce migration of COCs in riverbanks to sediment and surface water such that levels are acceptable in sediment and surface water for human health and ecological exposures.

1.2 FEDERAL NEXUS

The proposed action, which is described below, is being selected and implemented under CERCLA and must comply with applicable or relevant and appropriate requirements (ARARs). The Endangered Species Act (ESA) and the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) are ARARs.

1.3 CONSULTATION HISTORY

In 2002, EPA entered into a Memorandum of Understanding with parties, including both the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS), to provide the framework for the coordination and cooperation amongst these federal agencies, particularly with respect to incorporating USFWS and NMFS expertise regarding compliance under the ESA. In early 2009, EPA began coordination with NMFS regarding how to address Clean Water Act (CWA) Section 404(b)(1) and ESA consistency and compliance of the remedial alternatives in the FS. The LWG began developing the mitigation framework at that time in conjunction with EPA, NMFS, and other federal and state partners through a series of meetings and discussions. Work continued on the development of the framework in 2010 and 2011, with the basic information regarding the mitigation estimation approach provided to EPA in June 2011.

1.4 SCOPE OF THE ANALYSIS

This BA presents a programmatic-level evaluation of the proposed plan/proposed action for the Site to support formal consultation with the Services so that EPA and the Services may complete consultation prior to EPA's issuance of the ROD.

It is anticipated that a Site-wide biological opinion (BO) to be developed by NMFS based on this biological assessment (BA) would be sufficiently comprehensive to lay the framework for individual consultations, as necessary, such that it will streamline the implementation and completion of individual projects. It is understood that individual remedial actions may have sediment management area (SMA)-specific impacts that cannot be addressed with sufficient specificity in the Site-wide consultation; therefore, individual consultation would need to occur. However, the subsequent individual consultations, if necessary, could be tiered to the Site-wide consultation on EPA's ROD, thus, allowing for more timely and efficient remedy implementation.

Section 2 of this document describes the proposed action in more detail, including the avoidance and minimization measures that would be implemented during construction. Section 3 describes the species that are addressed in this BA, which are listed in **Table 1-1**. Section 4 provides information on baseline environmental conditions within the proposed action area. Section 5 presents an evaluation of the potential effects associated with the proposed action relative to physical, chemical, and biological indicators important to listed species. Section 6 presents an evaluation of effects on Essential Fish Habitat (EFH). Section 7 provides a complete list of the sources cited in the preparation of the BA.

2.0 DESCRIPTION OF THE PROPOSED ACTION

2.1 PROJECT LOCATION

The Site is located within the Lower Willamette River between approximately RM 1.9 and RM 11.8 as shown in **Figure 1-1**. Some riverbank areas with known contamination are also included as part of the Site under the proposed action (**Figure 1-2a-f**). The final boundaries for cleanup will be determined by EPA upon issuance of the ROD.

The Site is broken up into six distinct areas as described in the FS: the navigation channel, future maintenance dredge areas, intermediate areas, shallow areas, Swan Island Lagoon, and riverbanks. These designations were used to support the assignment of remedial technologies and the evaluation of remedial action alternatives in the FS. The navigation channel is the federally authorized navigation channel. Future maintenance dredge areas (FMD) are those areas near and around docks based on information regarding vessel activity, dock configuration and future site uses where maintenance dredging is likely to occur. Intermediate areas are defined as outside the horizontal limits of the navigation channel and FMD areas up to the bathymetric elevation of 4 feet North American Vertical Datum of 1988 (NAVD 88).

For the purposes of the FS, shallow areas are defined as shoreward of the bathymetric elevation of 4 feet NAVD 88; however, NMFS defines shallow area as those places with a water column depth of less than 20 feet as measured at Mean Lower Low Water (NMFS 2012). Since Mean Lower Low Water is at an elevation of 7 feet NAVD 88 at the Site, shallow water would extend to a depth of -13 feet NAVD 88. This NMFS definition will be used for the purposes of the effects evaluation presented in this BA.

2.2 REMEDIAL ALTERNATIVES DEVELOPMENT/BACKGROUND

The proposed action was developed based on the evaluation of remedial action alternatives presented in the FS and conducted in accordance with CERCLA and the National Contingency Plan (NCP), which entailed a comparison of the alternatives through the nine criteria provided for in the NCP.

Development of remedial alternatives is described in detail in Section 3 of the FS. The process for alternative development began with establishing RAOs. The RAOs, outlined in Section 1 of this document, consist of media-specific goals for protecting human health and the environment. Preliminary remediation goals (PRGs) were then identified based on the results of the baseline human health and ecological risk assessments, chemical-specific ARARs, when available, and consideration of background concentrations. PRGs represent concentrations in environmental media that are protective of both human and ecological receptors for each RAO. The area where contamination in sediments exceeds the human health PRGs in the RI/FS Study Area is approximately 2,450 acres (essentially the entire Study Area). However, the area where sediments exceed the ecological PRGs is 1,520 acres (64 percent of the Study Area). Based on this information, the entire river area from RM 1.9 to RM 11.8, including some riverbanks, is evaluated for actions under CERCLA authority because the area contains COC concentrations that exceed the PRG for at least one contaminant or are a potential source of contamination to the river. However, the entire river area may not need physical construction activities, such as capping or dredging, for the remedy to achieve remedial action objectives and cleanup levels.

To facilitate the development of remedial action alternatives, remedial action levels (RALs) were established. RALs are contaminant-specific sediment threshold concentrations used to identify the areas requiring capping or dredging and establish SMA boundaries. RALs were developed by considering the relationship between the spatial extent of contamination exceeding the RAL concentration (acres of capping or dredging) and the surface area weighted average concentrations (SWACs). A range of RALs consisting of six different concentrations was developed for each of the six focused COCs (PCBs, total PAHs, 2,3,7,8- Tetrachlorodibenzo-p-dioxin (TCDD), 1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD), 2,3,4,7,8-Pentachlorodibenzofuran (PeCDF), and DDx) for development of the remedial alternatives, as described in the next section.

Remedial technologies were assigned for each SMA based on anthropogenic and environmental site conditions. A multi-criteria decision matrix was used to score technologies based on multiple criteria related to hydrodynamics (wind/wave zones, erosive or depositional conditions, and depth), sediment bed characteristics (slope and substrate), and anthropogenic conditions (structures/pilings, prop wash zones, and debris). Three technology assignment decision trees were then developed for: 1) areas that are within the federally authorized navigation channel (navigation channel) or designated as FMD, 2) shallow areas, and 3) intermediate areas. Within these areas, technologies were assigned based on several factors, including the presence of principal threat waste (PTW), presence of heavy structures, depth of contamination, and others.

These decision trees were used to apply technologies across the Site and are the basis for the calculations of remedial areas and volumes defined for each alternative. Footprints of each technology assignment were developed in the FS based on the current dataset that EPA has for the Site; however, these footprints are subject to change based on new site information collected during remedial design. This may result in changes to the area and volume of sediment contamination requiring remediation but will not change the basic remedial technologies that have been assigned.

2.2.1 Alternatives Evaluated in the Feasibility Study

Seven remedial alternatives were developed (as described in detail in **Section 3** of the FS), including the no action alternative (designated as Alternative A). The no action alternative does not include any containment, removal, disposal, or treatment of contaminated sediments, no new institutional controls, and no new monitoring. There would be no construction or physical disturbance of the environment under this alternative.

Six remedial alternatives (designated as Alternatives B through G) were assembled by combining the remedial technologies and associated process options to address focused COCs above PRGs in sediments across the Site. Technologies were assigned based on site-specific characteristics so that remedial approaches most appropriate for site conditions (anthropogenic and environmental) would be applied within each SMA. Each of the six remedial alternatives applies the same suite of remedial technologies and process options to varying degrees based on the range of six RALs. The primary difference between Alternatives B through G is the size of the footprint of removal and containment based on the area of the SMAs defined for each alternative.

Based on tribal input, an additional alternative (Alternative I) was developed that entails active remediation to address all contaminated sediments at the site through dredging or containment.

2.2.2 Selection of the Proposed Action

The proposed action was selected in accordance with CERCLA, the NCP's remedial action alternatives evaluation, including a comparison of the alternatives through the nine criteria described in the NCP. The three criteria used for the initial screening of alternatives are effectiveness, implementability, and cost. Based on this initial screening, Alternative C was eliminated from further consideration because it did not present a viable option distinct from Alternative B. Alternative I was also eliminated based on implementability.

Section 4 of the FS provides a detailed analysis of the remaining five remedial alternatives and the no action alternative against each of NCP evaluation criteria and a comparative analysis that focuses upon the relative performance of each alternative against those criteria. Based on this analysis, each of the five remedial alternatives meets the seven threshold and balancing criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. One of the primary differences among the remedial alternatives is the time it would take to achieve RAOs. Alternative B would take the longest to achieve some RAOs because of the greater magnitude of residual risks that would remain as compared to other alternatives. These residual risks would result from areas that are not addressed by capping, dredging, in-situ treatment or enhanced monitored natural recovery (EMNR). Alternative B would also have the greatest dependence on the effectiveness of monitored natural recovery (MNR) and adherence to institutional controls (ICs) to meet the PRGs.

2.3 DESCRIPTION OF REMEDIAL TECHNOLOGIES

2.3.1 Institutional Controls

Existing Oregon Health Authority (OHA) fish consumption advisories would continue under the proposed action. Further, enhanced outreach to educate community members about the OHA consumption advisories and emphasize that advisories would remain in place during and after remediation would be incorporated into the active remedial alternatives. Outreach activities would focus on communities (typically communities or groups with environmental justice concerns) known to engage in sustenance fishing, with a special emphasis on sensitive populations (children, pregnant women, nursing mothers, tribal members). These activities could also include posting multilingual signs in fishing areas, distributing illustrated, multilingual brochures, and holding educational community meetings and workshops.

Additional institutional controls, such as waterway and land-use restrictions or special conditions to protect the integrity of engineered caps, imposed on sediment disturbance activities would also be implemented as components of alternatives comprising active remedial measures.

2.3.2 Monitored Natural Recovery

Natural recovery typically relies on ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. These processes may include physical (burial and sedimentation or dispersion and mixing), biological (biodegradation), and chemical (sorption and oxidation) mechanisms that act together to reduce the risk posed by the contaminants. However, not all natural processes result in risk reduction; some may increase or shift risk to other locations or receptors. MNR includes monitoring of the water column, sediment, and biota tissues to assess whether these natural processes continue to occur and at what rate they may be reducing contaminant concentrations in surface sediment but does not include active remedial measures. However, should monitoring determine that natural recovery is not occurring as expected, additional sediment cleanup and source control actions may be required.

2.3.3 Enhanced Monitored Natural Recovery

EMNR refers to enhancement or acceleration of natural recovery processes to reduce risks within an acceptable time frame. As with MNR, EMNR entails monitoring to assess whether natural processes continue to occur and at what rate they may be reducing contaminant concentrations in surface sediment. Areas that are stable (exhibit low shear stress) and are recovering naturally are candidates for EMNR. EMNR would be applicable to broad areas of the Study Area with lower levels of contamination, net sedimentation, and where significant erosion is not a concern.

A 12-inch layer of clean material (i.e., sand) would be used to accelerate natural recovery through several processes, including dilution of contaminant concentrations in sediment and decreasing exposure of organisms to the contaminated sediment. A thin-layer cover is typically different than the isolation caps because it is not designed to provide long-term chemical and physical isolation of contaminants and does not require that the layer be maintained.

The grain size and organic carbon content of the clean sediment to be used for a thin-layer cover would be selected to approximate common substrates found in the area and provide suitable habitat for benthic organisms native to the Lower Willamette River. Clean sediment can be placed in a uniform thin layer over the contaminated area or it can be placed in berms or windrows, allowing natural sediment transport processes to distribute the clean sediment to the desired areas.

2.3.4 Containment

Containment entails the physical isolation (sequestration) or immobilization of contaminated sediment by an engineered cap, thereby limiting potential exposure to, and mobility of, contaminants under the cap. Caps are designed to reduce potentially unacceptable risks through: 1) physical isolation of the contaminated sediment or soil to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface, 2) stabilization and erosion protection to reduce re-suspension or erosion and transport to other sites, and/or 3) chemical isolation of contaminated media to reduce exposure from contaminants transported into the water column. Capping technologies require long-term monitoring and maintenance in perpetuity to ensure that containment measures are performing successfully because contaminated sediment is left in place.

Caps are generally constructed of granular material, such as suitable fine-grained sediment, sand, or gravel, but can have more complex designs. Engineered sand caps, with and without stone armor, were selected as the representative process option for alternatives involving sediment containment. Caps would be designed with different layers (including "reactive" capping layers that provide treatment) to serve these primary functions or in some cases a single layer may serve multiple functions. Reactive caps were considered for areas where there are groundwater plumes, contaminants that have higher water solubility in areas with significant groundwater advection (the process by which contaminants are transported by flowing groundwater), or where thinner caps are needed in order to minimize any increase in flood potential. Specific cap types included in the FS include:

- Significantly augmented reactive cap (17" fine-grained low permeability sand, 1" organoclay mat, 12" medium sand)
- Reactive cap (12" sand w/ 5 percent granular activated carbon [GAC], 24" sand)
- Reactive cap with beach mix (12" sand w/ 5 percent GAC, 18" sand, 6" beach mix)
- Reactive armored cap (12" sand w/ 5 percent GAC, 12" sand, 12" armor stone)
- Reactive armored cap with impermeable layer (6" Aquablok, 6" beach mix)
- Engineered cap (36" sand)
- Engineered cap with beach mix (30" sand, 6" beach mix)
- Armored cap (24" sand, 12" armor stone)

2.3.5 In-Situ Treatment

In-situ treatment of sediments refers to chemical, physical, or biological techniques for reducing contaminant concentrations, toxicity, bioavailability, or mobility while leaving the contaminated sediment in place.

In-situ treatment likely would entail sequestration by addition of an amendment such as activated carbon to the sediments, which modifies the sorption capacity of non-polar organics and certain metals such as mercury. Amendments can be engineered to facilitate placement in aquatic environments by using an aggregate core (such as gravel) that acts as a weighting component and resists re-suspension, so that the mixture is reliably delivered to the sediment bed where it breaks down slowly and mixes into sediment by bioturbation.

The FS assumed that in-situ treatment will be accomplished through the placement of 12 inches of AquaGate with an activated carbon content of 5 percent by weight. Site-specific treatability studies may be required during remedial design to determine the effectiveness of the treatment technology in the environment of the Study Area and to develop specific design characteristics such as the activated carbon application rate.

2.3.6 Sediment/Soil Removal

Removal of sediments can be accomplished either while submerged (dredging) or after water has been diverted or drained (excavation). Both methods typically necessitate transporting the sediment to an offloading facility for dewatering followed by transport to a Subtitle D or Subtitle C/Toxic Substances Control Act (TSCA) landfill. For non-aqueous phase liquid (NAPL) and/or not reliably containable PTW, treatment through solidification/stabilization or thermal desorption would be required prior to disposal. Treatment of water from dewatered sediment prior to discharge to an appropriate receiving water body may also be required. It should be noted that there is ongoing navigation dredging throughout the site to maintain waterways for recreational, national defense, and commercial purposes.

The FS assumed that sediments would be removed using mechanical dredging techniques. Environmental/closed buckets and fixed arm dredges are the preferred method for dredging. However, cable-operated dredges may be required in certain conditions such as where water depths exceed 40 feet. In addition, traditional clamshell buckets may be required in certain conditions such areas with significant debris. The specific method for sediment removal will be determined during remedial design.

It is assumed that land-based excavators would be used for removal of contaminated riverbank materials or near-shore sediments in locations above the water level present at the time of the work to limit offsite transport of disturbed riverbank materials by the river. It is assumed that removal of riverbank material would be conducted in the late summer and early fall when river stage is low.

2.3.7 Ex-Situ Treatment

Ex-situ treatment involves the application of chemical, physical or biological technologies to transform, destroy, or immobilize contaminants following removal of contaminated sediments. Depending on the contaminants, their concentrations, and the composition of the sediment, treatment of the sediment to reduce the toxicity, mobility, or volume of the contaminants before disposal may be warranted. Available disposal options and capacities may also affect the decision to treat some sediment. Regulatory requirements may influence the need for treatment (such as Resource Conservation and Recovery Act [RCRA] Land Disposal Restrictions) and a determination that some portion of the material constitutes PTW and, as such, treatment would be considered. Ex-situ treatment technologies evaluated in the FS include thermal treatment and solidification/stabilization using quicklime.

Dewatering of dredged sediments would be required prior to ex-situ treatment. Dewatering is described in Section 2.3.8.1.1.

2.3.8 Disposal

Disposal refers to the placement of dredged or excavated material and process wastes into a temporary or permanent structure, site, or facility. The goal of disposal is generally to manage sediment and/or residual wastes to prevent contaminants associated with them from impacting human health and the environment.

Disposal of removed media can either be within an upland landfill disposal facility, such as operating commercial landfills, or within an in-water disposal facility specifically engineered for the sediment remediation such as in a confined disposal facility (CDF). Landfill disposal options considered in the FS include disposal in a RCRA Subtitle D landfill and RCRA Subtitle C or TSCA landfills.

2.3.8.1 Upland Disposal

Dredged sediments meeting certain criteria would be disposed of at upland landfill disposal facilities. Prior to transport, sediments would be dewatered, and the wastewater would be treated, as described below. Transport options are also discussed.

2.3.8.1.1 Dewatering

Dewatering technologies are commonly used to reduce the amount of water in dredged sediment and prepare the sediment for transport and treatment or disposal. In many cases, the dewatering effluent will need to be treated before it can be disposed of properly or discharged back to receiving water. Dewatering also would occur with ex-situ treatment. Several factors would be considered when selecting an appropriate dewatering treatment technology including physical characteristics of the sediment; selected dredging method; and the required moisture content of the material to allow for the next handling, treatment, transport, or disposal steps in the process. The specific dewatering technology will be determined during remedial design based on the characteristics of the removed sediment.

Three categories of dewatering that are regularly implemented include passive dewatering, mechanical dewatering, and reagent enhanced dewatering/stabilizing methods.

Passive Dewatering

Passive dewatering (also referred to as gravity dewatering) is facilitated through natural evaporation, consolidation, and drainage of sediment pore water to reduce the dredged sediment water content. It is most often conducted at an onshore temporary holding facility such as a dewatering lagoon or temporary settling basin. In-barge settling and subsequent decanting can also be an effective passive dewatering method and can reduce the overall time needed for onshore passive dewatering operations. Water generated during the dewatering process is typically discharged to receiving waters directly after some level of treatment or may be captured and transported to an offsite treatment and discharge location. Normal passive dewatering typically requires little or no treatability testing although characteristics of the sediment, such as grain size, plasticity, settling characteristics and NAPL content, are typically considered to determine specific dewatering methods, size the dewatering area, and estimate the time frame required for implementation.

Passive dewatering is generally effective and capable of handling variable process flow rates but can require significant amounts of space (depending on the volume of material processed and the settling characteristics of the sediment) and time for significant water content reduction. Passive dewatering is a widely implemented dewatering technology for mechanically dredged sediments. It is also amenable to hydraulic dredging with placement into a settling basin or with the use of very large geotextile tubes to confine slurry and sediment during passive dewatering. Hydraulic dredge sediment dewatering with geotextile tubes has been implemented at several sites but typically requires project-specific bench-scale evaluations during remedial design to confirm its compatibility with Site sediments and properly select and size the geotextile tubes. Under this method, geotextile tubes would be placed in upland locations.

Mechanical Dewatering

Mechanical dewatering involves the use of equipment, such as centrifuges, hydrocyclones, belt presses, or plate-and-frame filter presses, to separate coarse materials or squeeze, press, or otherwise draw water out from sediment pore spaces. Mechanical dewatering is typically used in combination with hydraulic dredging to reduce the water content of the dredged slurry prior to ex-situ treatment (e.g., thermal) and/or disposal of the dewatered sediment. Mechanical dewatering may also be used in combination with mechanical dredging if the dredged material is hydraulically re-slurried from the barge. Sufficient onshore space is needed to accommodate the selected dewatering equipment, but this space is usually less than required for passive dewatering.

The mechanical dewatering treatment train typically includes screening to remove materials such as debris, rocks, and coarse gravel. If appropriate, polymers may be added for thickening prior to dewatering. These steps result in a dewatered cake that achieves project-specific volume and weight reduction goals for the dredged sediment. The mechanical dewatering process can be scaled to handle large volumes of sediment but requires operator attention, consistent flow rates, and consistent sediment feed quality.

Reagent Dewatering

Reagent dewatering is an ex-situ treatment method in the category of stabilization/solidification methods. This technology removes water by adding a reagent to the bulk sediment that binds with the water within the sediment matrix to immobilize the leachable contaminants (typically metals) and/or enhance geotechnical properties. This process increases the mass of the sediment due to the addition of the reagent mass. For situations where dewatering is the single goal, the most cost-effective, available, and effective reagent or absorptive additive is used, which, depending on site conditions and economics, could include quicklime, Portland cement, fly ash, diatomaceous earth, or sawdust, among others. Reagent mixtures can be optimized to provide enhanced strength or leachate retardation to meet specific project requirements.

Dewatering by the addition of reagents is effective and has similar or smaller space and operational requirements as compared to mechanical dewatering. In some cases, reagent addition and mixing can be conducted as part of the dredged material transport and handling processes, either on the barge or as dredged material is loaded into trucks or rail cars. In other cases, it can be added and mixed after offloading to an upland staging area. Also reagent addition may be used in combination with other forms of dewatering (e.g., filter press) and ex-situ treatment. The Gasco Early Action project used in-barge application and mixing of Portland cement as well as diatomaceous earth at the transload facility as a final dewatering "polishing" step. This approach required no extra upland treatment space or major changes to the transport and transload steps that would have been needed otherwise.

2.3.8.1.2 Wastewater Treatment

Dewatering dredged material requires managing the wastewater generated during the dewatering process (dredged material typically has a water content ranging from 50 to 98 percent, depending on the dredging method) along with contact water (such as precipitation that has been in contact with contaminated material, decontamination water, and wheel wash water) from other facility operations. The purpose of wastewater treatment is to prevent adverse impacts on the receiving water body from the discharge of dewatering water to the Lower Willamette River.

Wastewater will be generated by dewatering steps, and this water likely will either require treatment prior to discharge to the Lower Willamette River or disposal at a publicly owned treatment works (POTW) facility. While the FS necessarily assumes a representative set of process options for the general screening and alternative development procedures, this does not imply that other process options are screened out from future consideration during remedial design. Unless specifically noted otherwise, all process options discussed in this section would be potential options during remedial design. For example, there may be opportunities for handling and discharging dewater, including addition of amendments to bind or absorb water, use of upland transfer or disposal holding areas to allow water to clarify before discharge, and discharge to publicly operated existing treatment facilities.

A wastewater treatment plant may be included as part of the onsite management of dredged material. An onsite wastewater treatment plant to manage wastewater for a facility handling sediment from the Portland Harbor Site may include coagulation, clarification, multi-stage filtration, and granular activated carbon adsorption with provision for metals removal, if necessary. The primary difference in the wastewater treatment plant for a hydraulic dredging operation as compared to a mechanical dredging operation would be the volume of wastewater to be treated. As hydraulic dredging results in a larger volume of sediment-water slurry to be managed, a hydraulic dredging wastewater treatment plant would require a larger footprint.

2.3.8.1.2 Transportation

Transportation would be a necessary component of removal of contaminated sediments from the Portland Harbor Site. The transportation method would be based upon the compatibility of that transportation method to the other process options. The most likely transportation methods are truck, rail, and barge. These are briefly discussed below.

Truck Transport
Truck transportation includes the transport of dewatered dredged material over public roadways using dump trucks, roll-off boxes, or trailers.

Rail Transport
Rail transportation includes the transport of dewatered dredged material via railroad tracks using gondolas or containers. Rail transport is desirable where sediment is shipped over long distances, for example, to out-of-state treatment or disposal facilities. Rail transport may require the construction of a rail spur from a sediment handling facility to a main rail line.

Barge Transport
Barge transportation includes the transport of dredged solids directly to a processing (dewatering) or disposal (CDF) facility or the transport of dewatered dredged material to a transloading or disposal facility. Barge transport likely would be used for short distances such as from the dredging location to the dredged material handling facility. In addition, barge transport may be considered for longer distances if dredged material is hauled to treatment or disposal locations that have the ability to accept barge-loaded dredged material. Sediment would be dredged from SMAs within the Site, loaded onto barges, taken to a transloading facility where it would be prepared for upland transportation and transferred to rail or truck, and then transported to the landfill for disposal. Potential upland disposal facilities are shown in **Figure 2-2**.

Transloading of Sediments and Debris
Transloading of sediments and debris will be conducted at an upland offload facility. Improvements at the offload facility may include pavement improvements, stormwater

management berms, watertight transload box installation, drying agent storage, a truck lining station, a truck covering station, and a dry decontamination station.

2.3.8.2 Confined Disposal Facility

Dredged material would be disposed of within a CDF, an in-water disposal facility specifically engineered for the sediment remediation. A CDF would be more efficiently integrated with dredging because it could result in shorter transport distances and minimize the need to off-load at an offsite landfill.

Construction of a CDF would occur in Slip 1 of the Port of Portland's Terminal 4, as shown in **Figure 2-3**. The CDF would fill approximately 14 acres of aquatic habitat (Anchor QEA 2011). Construction would entail demolition of overwater structures and pilings and construction of the containment berm at the mouth of Slip 1 (including dredging the 5- to 10-foot-deep "key" beneath the proposed containment berm location at approximately -40 feet National Geodetic Vertical Datum [NGVD]). This sediment would be removed from its current location and placed at the head of Slip 1 prior to containment berm construction. The CDF berm would be constructed at a 2:1 side slope, with the exception of a more gently sloped bench (20 percent or 5:1) on the outside face of the berm (**Figure 2-4**). Once construction of the CDF berm is complete, the CDF would be fully enclosed from the river and placement of sediments into the CDF would not be considered in-water work.

Construction of the CDF berm would include a weir and outfall structure that would be used to drain water from the CDF as it is being filled with sediment. This structure would consist of a pipe and a weir structure through which effluent, when necessary, would outlet at the waterward face of the containment berm into the Willamette River. During filling, as water within the CDF begins to approach a level at which discharge is necessary, water quality within the CDF would be sampled prior to discharge to confirm that water quality criteria will be achieved at the compliance boundary outside of the CDF to be established in the NMFS BO and CWA Section 401 Water Quality Certification for the project.

2.3.9 Removal and Installation of Pilings and Structures

Some piles and structures will need to be removed during dredging and capping. Structures may also be installed for work area isolation, sediment containment, or fish exclusion during construction. It is expected that piles and dilapidated structures with low function, permanence, and lifespan will be removed. Major and minor structures with medium to high function, permanence, and lifespan are expected to remain in place. Temporary docks are expected to be relocated to allow access to contaminated material. Structures will be removed using marine salvage equipment. Piles can either be removed or cut off at the base using divers. At many locations, creosote treated piling will be replaced with a different piling type, which will remove a minimal source of PAHs to the sediment.

2.4 PROJECT DESCRIPTION

The proposed action consists of remedial technologies to be implemented at the Site to reduce potential risks from contaminated sediments and surface water to acceptable levels consistent with the RAOs established for the Site in the FS. Remedial actions focus on reductions in concentrations of contaminants in sediment and riverbank soils. The proposed action includes implementation of remedial technologies to address concentrations of contaminants in sediment and riverbank soils, and disposal of contaminated sediments in a CDF. These remedial actions, in conjunction with source control measures implemented under state or federal authority, are anticipated to reduce concentrations in other media such as groundwater, stormwater, surface water, upland soils, and air.

Based on the evaluation presented in the FS, EPA identified Alternative E as the preferred alternative, with some modifications at specific areas of the Site. In some cases, modifications were made to apply technologies based on more stringent RALs (Alternative F) in certain areas to ensure that cancer risk and noncancer hazard levels throughout the Site will be within an acceptable range. In other cases, modifications would apply technologies under less stringent RALs (Alternatives B and D) while requiring that all PTW is still addressed.

The footprint of removal and containment for the proposed action (also known as the preferred alternative, the optimized alternative, or Alternative H) is shown on **Figures 2-1(a-f)**. The area of each assigned technology is presented in detail in **Table 2-1**. Information on material volumes is provided in **Table 2-2** for the Site and **Table 2-3** for riverbanks. The expected years to complete construction is provided in **Table 2-4**.

2.5 IMPACT AVOIDANCE AND MINIMIZATION MEASURES AND CONSERVATION MEASURES

Impact avoidance and minimization measures for the proposed action apply to remedial technologies, including dredging, capping, piling and structure removal and installation implemented as part of the proposed action, and construction of compensatory mitigation projects. Section 5 of this BA presents an evaluation of the potential impacts from the proposed action. The avoidance and minimization measures described in this section are measures taken to first avoid those impacts to the aquatic environment, but where impacts may be unavoidable, measures to minimize the impacts need to be taken. The avoidance and minimization measures described in this section were developed as part of the FS and informed by previous BA analyses and associated BOs for removal actions that have taken place in the lower Willamette River, including Arkema, Gasco, and Terminal 4 Early Action sites.

Some of the minimization measures described in this section were developed to serve as "on-site mitigation" to be integrated into the remediation plan to maintain habitat and function that would be altered during implementation of the proposed action. As described in Section 2.5.4, these integrated minimization measures include the use of beach mix as a final substrate layer following dredging and capping and the restoration of water depth, slope, riparian vegetation where possible, and riverbank slope modification where applicable. These measures would be employed to avoid the need for compensatory mitigation (and are required to be considered prior to use of compensatory mitigation for ESA-listed and/or non ESA-listed species).

Given the general level of design in an FS, the degree of integrated minimization measures that will take place during implementation of the proposed action will be determined during remedial design. It is anticipated that compensatory mitigation pursuant to CWA Section 404 will be required as part of the proposed action to offset impacts that cannot be avoided or minimized through the use of on-site “mitigation” and other measures described in this section. In lieu of SMA-specific information to be obtained during remedial design, a programmatic approach was used to estimate compensatory mitigation requirements for the FS. This is a useful and straightforward approach for the purposes of the FS, which is not expected to greatly impact the selection of the preferred alternative by EPA. Implementation of avoidance and minimization measures discussed in this section will reduce the impacts to listed species and critical habitat in the action area. Although implementation of the proposed action may cause short-term impacts to the function of salmonid critical habitat, implementation of the CWA Section 404(b)(1) compensatory mitigation requirements will replace any lost habitat functions.

As described in the FS Appendix J, determination of required compensatory mitigation on an SMA-specific basis during remedial design will be based on an approach that relates existing habitat to the highest functioning rearing and migration habitat and provides mitigation acreages relative to the creation of this highest functioning habitat. Highest functioning habitat is defined as off channel, shallow water, or active channel margin (ACM) with a gentle slope (shallower than 5:1), habitat complexity in the form of large woody debris, and sand and gravel substrate.

2.5.1 In-Water Work

The following impact avoidance and minimization measures will apply to all construction activities:

- The potential for adverse effects to ESA-listed species should be minimized to the degree possible by conducting all in-water work within an approved in-water work window when salmonids are expected to be either not present or present only in low numbers. The work window requirement is expected to apply to activities occurring in the water that have the potential to impact listed species. In-water work would be conducted between approximately July 1 and October 31

- Potential activities that would be conducted within an approved in-water work window include the following:

    - MNR monitoring – collection of biota for tissue sampling activities only

    - In-place technologies

   - Dredging
   - Disposal of dredged material – transport and offloading of sediment for upland placement of material into a landfill
   - Construction of the CDF berm
   - Removal and installation of pilings
   - Construction of compensatory mitigation projects

- Potential activities that can occur throughout the year outside of an in-water work window include but may not be limited to:
   - Filling of the CDF once the berm is complete.
   - Surface sediment and surface water collection activities and other types of sampling and monitoring are expected to occur during any time period throughout the year due to the limited impact to listed species expected to result from these collection activities.
   - Transport and offloading of sediment for upland placement of material into a landfill is expected to occur during any time period throughout the year due to the limited impact expected to result from these activities.
   - Removal and replacement of light structures (without pile driving) is expected to occur during any time period throughout the year due to the limited impact expected to result from this activity.
   - Activities occurring in the dry or over the water are expected to occur outside of the work window with proper measures in place to prevent construction materials from dropping into the water.
   - Activities occurring inside sheet pile wall containment that isolates the activity from the surrounding water column.

- Water Quality Monitoring- Remedial actions will comply with detailed water quality monitoring and control requirements set forth in a Water Quality Monitoring and Compliance Conditions Plan (WQMCCP). It is assumed those requirements will include, at a minimum, turbidity monitoring and initial chemical constituent monitoring, sediment and contaminant dispersion control measures such as silt curtains, sheet pile walls, and closed or environmental dredge buckets and best management practices (BMPs). In addition, an appropriate escalation of conditions could include work slowing/stoppage and/or additional monitoring if exceedances are detected or if injured or dead ESA-listed species or non ESA-listed species are observed in the project area and if it is determined that the injuries are related to construction operations. NMFS law enforcement personnel should be notified, and fish should be handled with care to ensure effective treatment or analysis of cause of death or injury.

Chemical Parameter Monitoring: The requirements of chemical parameter monitoring, including compliance points and concentrations, would be established in a WQMCCP prior to SMA-specific project implementation.

Turbidity Monitoring:

- The compliance point for turbidity is 100 meters downstream of the expected location of the center of the in-water work activity. At the point of compliance, turbidity shall not exceed 5 nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU. At no time should turbidity exceed 50 NTU over background. Should this occur, then all in-water activities shall cease immediately, and EPA shall be notified. Work shall not resume until turbidity levels have returned to compliant levels and approval has been given by EPA.

- All monitoring station locations will be determined using a laser range finder, which is accurate to within ±1 meter. Sampling depths for turbidity will be located at the approximate top, middle, and bottom of the water column if the water depth permits collecting samples from three intervals separated by at least 5 feet from each other. Top and bottom samples will be taken 1 foot below the surface of the water and above the mud line, respectively. Thus, for water depths less than 7 feet, two samples will be collected and for water depths less than 2 feet, one sample will be collected.

- Background turbidity will be established prior to the start of any active in-water work. A minimum of seven independent measurements at all applicable water depths will be made at least 100 meters upstream of the expected location of the center of the in-water work activity over the course of a two-day period just prior to construction initiation. The upstream distance for monitoring background conditions should target a relatively undisturbed and unimpacted area upcurrent from the work area, considering tidal influence. For NTU measurements, the 90th percentile upper confidence limit on the mean will be used to represent initial background conditions.

- As the Lower Willamette River is tidally influenced, if flow reversal is observed to occur during monitoring, then the sampling stations will be reversed to continue the down-current and up-current (for background conditions) pattern as appropriate. Measurements of current velocities and/or turbidity plumes will be required to confirm field observations and decisions on monitoring locations relative to tidal influence.

Monitoring Frequency:

- Turbidity will be measured at the start of each operation at least once every hour during active in-water work. On any day active in-water work occurs, the first sample will be taken 1 hour after the initiation of the activity, and once at each 1-hour interval thereafter. This frequency of monitoring for turbidity will continue until four consecutive hourly events indicate no exceedance of any trigger levels. If no exceedance is identified following four consecutive hourly events, the sampling frequency will be reduced to every 4 hours. Hourly frequency will resume if a turbidity exceedance has been confirmed and corrected.

Reporting:

- Turbidity exceedances will be reported as soon as possible on the day of measurement verbally or by email to EPA so that response decisions can be coordinated. As noted above, all in-water activities shall cease immediately if there is a turbidity exceedance. Work shall not resume until turbidity levels have returned to compliant levels and approval has been given by EPA.

Contingency Measures:

- In addition to turbidity monitoring, the cause of any observed silt plume generated by construction activities will be assessed and appropriate measures (e.g., change production rates, modify work schedule, perform work on a slower flow, etc.) will be taken in consultation with EPA to correct an identified problem if project operations are determined to be the source.

- During construction, activities that have the potential to produce sheens, surface booms, oil-absorbent pads, and/or similar materials should be on site and available for use.

- Prior to entering the water, all equipment should be checked for leaks and completely cleaned of any external petroleum products, hydraulic fluid, coolants, and other deleterious materials.

- Work barges should not ground out on the river bottom.

- Waste materials should be disposed of in an appropriate location according to the properties of the waste.

- Demolition and construction materials should generally not be stored in areas where materials could easily enter surface waters.

- A Spill Prevention, Containment and Countermeasure (SPCC) Plan should be developed for activities that have the potential to spill petroleum products and for general construction-related impacts to minimize potential adverse effects as follows:

- The SPCC Plan should discuss construction planning elements and recognize potential spill sources at the Site. The SPCC Plan should discuss potential responsive actions in the event of a spill or release and provide notification and reporting procedures. The SPCC Plan should contain contractor management elements such as personnel responsibilities, project site security, site inspections, and training.

- The SPCC Plan should describe measures that could be taken by the contractor to prevent the release or spread of hazardous materials, either found on site and encountered during construction but not identified in contract documents, or any hazardous materials that the contractor stores, uses, or generates on the construction site during construction activities.

- The contractor should maintain at the job site the applicable equipment and material designated in the SPCC Plan.

- Work area isolation

  - Isolate any work area within the wetted channel from the active stream whenever ESA-listed fish are reasonably certain to be present or if the work area is less than 300 feet upstream from known spawning habitats.

  - Engineering design plans for work area isolation must include all isolation elements and fish release areas.

  - Dewater the shortest linear extent of work area practicable, unless wetted instream work is deemed to be minimally harmful to fish and is beneficial to other aquatic species.

    - Use a coffer dam and a bypass culvert or pipe or a lined, non-erodible diversion ditch to divert flow around the dewatered area. Dissipate flow energy to prevent damage to riparian vegetation or stream channel and provide safe downstream reentry of fish, preferably into pool habitat with cover.

    - Where gravity feed is not possible, pump water from the work site to avoid rewatering. Maintain a fish screen on the pump intake to avoid juvenile fish entrainment.

    - Pump seepage water to a temporary storage and treatment site, or into upland areas, to allow water to percolate through soil or to filter through vegetation before reentering the stream channel with a treatment system comprised of either a hay bale basin or other sediment control device.

    - Monitor below the construction site to prevent stranding of aquatic organisms.

        - When construction is complete, re-water the construction site slowly to prevent loss of surface flow downstream and a sudden increase in stream turbidity.

    - Whenever a pump is used to dewater the isolation area and ESA-listed fish may be present, a fish screen must be used that meets the most current version of NMFS's fish screen criteria (NMFS 2011d). NMFS approval is required for pumping that exceeds 3 cubic feet per second.

- Fish capture and removal. Whenever work isolation is required and ESA-listed fish are likely to be present, the applicant must attempt to capture and remove the fish as follows (NMFS 2013):

    - If practicable, allow listed fish species to migrate out of the work area or remove fish before dewatering; otherwise, remove fish from an exclusion area as it is slowly dewatered with methods such as hand or dip-nets, seining, and trapping with minnow traps (or gee-minnow traps).

    - Fish capture must be supervised by a qualified fisheries biologist with experience in work area isolation and competent to ensure the safe handling of all fish.

    - Conduct fish capture activities during periods of the day with the coolest air and water temperatures possible, normally early in the morning, to minimize stress and injury of species present.

    - Monitor the nets frequently enough to ensure they stay secured to the banks and free of organic accumulation.

    - Electrofishing may be used only after other means of fish capture are determined to be not feasible or ineffective during the coolest time of day.

        - Do not electrofish when the water appears turbid (e.g., when objects are not visible at depth of 12 inches).

        - Do not intentionally contact fish with the anode.

        - Follow NMFS (2000) electrofishing guidelines, including use of only direct current (DC) or pulsed direct current within the following ranges:

            - If conductivity is less than 100 microsiemens (µs), use 900 to 1100 volts.

            - If conductivity is between 100 and 300 µs, use 500 to 800 volts.

      - If conductivity is greater than 300 µs, use less than 400 volts.

    - Begin electrofishing with a minimum pulse width and recommended voltage, then gradually increase to the point where fish are immobilized.

    - Immediately discontinue electrofishing if fish are killed or injured (i.e., dark bands visible on the body, spinal deformations, significant descaling, torpid or inability to maintain upright attitude after sufficient recovery time). Recheck machine settings, water temperature, and conductivity and adjust or postpone procedures as necessary to reduce injuries.

  - If buckets are used to transport fish:

    - Minimize the time fish are in a transport bucket.

    - Keep buckets in shaded areas or, if no shade is available, covered by a canopy.

    - Limit the number of fish within a bucket; fish will be of relatively comparable size to minimize predation.

    - Use aerators or replace the water in the buckets at least every 15 minutes with cold clear water.

    - Release fish in an area upstream with adequate cover and flow refuge; downstream is acceptable, provided the release site is below the influence of construction.

    - Be careful to avoid mortality counting errors.

  - Monitor and record fish presence, handling, and injury during all phases of fish capture and submit a fish salvage report to the U.S. Army Corps of Engineers (USACE) and NMFS within 10 days.

- Turbidity monitoring - in accordance with NMFS (2013), the following turbidity monitoring steps will be followed during remedial activities that have the potential to disturb sediments:

  - Take a turbidity sample using an appropriately and regularly calibrated turbidimeter, or a visual turbidity observation, every 4 hours when work is being completed or more often as necessary to ensure that the in-water work area is not contributing visible sediment to water. The sample shall be taken at a relatively undisturbed area approximately 100 feet upstream from the project area. Record the observation, location, and time before monitoring at the downstream point.

- Take a second visual observation, immediately after each upstream observation, approximately 200 feet from the discharge point or nonpoint source (for streams greater than 100 feet wide). Record the downstream observation, location, and time.

- Compare the upstream and downstream observations; if more turbidity or pollutants are visible downstream than upstream, the activity must be modified to reduce pollution. Continue to monitor every 4 hours or more often as necessary.

- If the exceedance continues after the second monitoring interval, the activity must stop until the pollutant level returns to background.

- If monitoring or inspections show that the pollution controls are ineffective, immediately mobilize work crews to repair, replace, or reinforce controls as necessary.

- Contaminant monitoring - monitoring for one or more key COCs will be conducted for dredging and for certain capping projects to ensure that BMPs are effective at reducing not only turbidity from the work but also offsite migration of dissolved and particulate COCs. This monitoring may include measures such as surface, mid water column, and over bottom water samples and other measures such as sediment traps. Site-specific plans will describe where this might be discontinued for longer term projects where elevated levels are not detected from in-water work.

- Pile removal and installation - pile removal and installation will be limited to the Lower Willamette River. In some places, piles may be replaced following remedial activities. In accordance with NMFS (2012) and EPA (2016), the following measures would be implemented during pile removal and installation.

<u>Piling removal- General BMPs</u>. Use the following steps to minimize creosote release, sediment disturbance, and sediment resuspension:

1. Prior to commencement of the work the project engineer or contractor should assess the condition of the piling, and identify whether piling will be removed using a barge or upland equipment. The contractor’s work plan must include procedures for extracting and handling piling that break off during removal. In general, complete extraction of piling is always preferable to partial removal.

2. When possible, removal of treated wood piling should occur in the dry or during low water conditions. Doing so increases the chances that the piling won’t be

broken (greater visibility by the operator) and increases the chances of retrieval in the event that piling are broken.

3. The crane operator shall remove piling slowly. This will minimize turbidity in the water column as well as sediment disturbance.

4. The operator shall minimize overall damage to treated wood piling during removal. In particular, treated wood piling must not be broken off intentionally by twisting, bending or other deformation. This will help reduce the release of wood-treating compounds (e.g., creosote) and wood debris to the water column and sediments.

5. Upon removal from the substrate and water column, the piling shall be moved expeditiously into the containment area for processing, and disposal at an approved off-site, upland facility (see #24 and #25 below).

6. The piling shall not be shaken, hosed-off, stripped or scraped off, left hanging to drip or any other action intended to clean or remove adhering material from the piling. Any sediment associated with removed piling must not be returned to the waterway. Adhered sediments associated with treated piling are likely contaminated and may, along with piling, require special handling and disposal.

7. The operator shall make multiple attempts to remove a pile before resorting to cutting.

Piling Removal - Vibratory Extraction Specific BMPs

Vibratory extraction is the preferred method of piling removal because it causes the least disturbance to the seabed, river or lake bed and it typically results in the complete removal of the piling from the aquatic environment.

8. The operator should “wake up” piling by vibrating to break the skin friction bond between piling and sediment. This bond breaking avoids pulling out a large block of sediment and possibly breaking off the piling in the process.

Piling Removal - Direct Pull Extraction Specific BMPs

Direct pull extraction refers to the removal of piling by grabbing or wrapping the piling and then directly pulling the piling from the sediment – using a crane or other large machinery. For example, piling are wrapped with a choker cable or chain and then removed by crane with a direct upward pull. Another method could involve an excavator with a pincer attachment that can grasp a pile and remove it with a direct upward pull. The use of direct pull can be combined with initial vibratory extraction.

9. Excavation of sediment from around the base of a pile may be required to gain access to portions of the pile that are sound, and to allow for extraction using direct pull methods. Excavation may be performed in-the-dry at low tide or in the water using divers. Hydraulic jetting devices should not be used to move sediment

away from piling, in order to minimize turbidity and releases to the water column and surrounding sediments.

<u>Piling Removal - Clamshell Bucket Extraction Specific BMPs</u>

Clamshell removal of piling uses a barge-based or upland excavator-mounted clamshell bucket. The clamshell is lowered from a crane and the jaws grasp the piling stub as the crane pulls up. Clamshell bucket extraction has the potential to disturb sediments if deployed close to the sediment surface and increases the likelihood of damaging piling which can result in incomplete removal of a pile. However, a clamshell bucket may be needed when broken or damaged piling cannot be removed using vibratory or direct pull extraction methods. Extraction with a clamshell might be the best way to remove piling that were cut at or below the mudline previously and have little or no stub accessible above the mudline.

10. To the extent possible, clamshell extraction should be performed in the dry during low tide, low river flows, or reservoir draw-down. Under these conditions, the operator can see the removal site and piling, improving the chance for full removal of piling.

11. Since sediment management is potentially a larger concern when using a bucket, every effort should be made to properly size the bucket to the job and operate it in ways that minimize sediment disturbance.

12. Excavation of sediment from around the base of a pile may be needed to gain access to portions of the pile that are sound, and to allow for extraction using a clam shell. Excavation may be performed in-the-dry at low tide or in the water using divers. Hydraulic jetting devices should not be used to move sediment away from piling, in order to minimize turbidity and releases to the water column and surrounding sediments.

13. Because clamshell extraction has a higher potential to generate debris, it is particularly important that an offshore boom be in place with this removal technique. If treated wood piling are being removed, extracted piles shall be transferred to the containment basin without leaving the boomed area to prevent loss of treated wood chemicals (e.g., creosote) and debris to the water column and sediments.

14. The operator must minimize pinching of treated wood and overall damage to treated wood piling during removal. This will help reduce the potential for releasing treated wood chemicals (e.g., creosote) and debris to the water column and sediments.

<u>15. No grubbing for broken piling is allowed.</u>

<u>Additional Pile Removal BMPs for Locations with Contaminated Sediments:</u>

- During project planning, consider that the best tidal condition for piling removal will be dictated by the specifics of the removal. For example, in some circumstances water access for removal equipment at high tide may be less disturbing to the sediment than access in the dry at low tide. In others, removal in the dry is the best option.

- During project planning, consider the pros/cons of each method and its potential to disturb contaminated sediments. For example, while a clamshell bucket may be more feasible for removal of buried or broken piling, it is also more likely to disturb sediments. It may be preferable to manually excavate and remove by direct pull.

- Based on EPA's experience at numerous Superfund cleanup sites (e.g., Pacific Sound Resources, Olympic View, Ketchikan Pulp Mill and Lockheed), extraction of piling is not expected to result in exposure to subsurface contaminated sediments via an exposed "hole". Therefore EPA does not require placement of sand prior to or after pile pulling, unless it is part of an overall project design, such as a cap. Undocumented placement of clean sand may complicate future characterization efforts at cleanup sites.

- If piling removal results in exceedance of turbidity or other water quality standards at the compliance boundary, reconsider the timing of removal to a more restricted time frame, for example, the lowest practical tide condition or around slack water.

<u>Piling Removal - Pile Cutting Specific BMPs</u>

Pile cutting shall be considered a last resort following multiple attempts to fully extract piling using vibratory, direct pull, and/or clamshell bucket extraction. On a project-specific basis, pile cutting may be appropriate to maintain slope stability or if a pile is broken and cannot be removed by other methods. A pneumatic underwater chainsaw, shearing equipment, or other equipment should be used to cut a pile.

16. Piling shall be cut below the mudline, with consideration given to the mudline elevation, slope and stability of the site.

17. In intertidal and shallow subtidal areas (shallower than -10 feet MLLW) seasonal accretion and erosion of the nearshore and/or beach can expose cutoff piling. In these locations, piling should be cut off at least 2-feet below the mudline. In deeper subtidal areas (deeper than -10 feet MLLW), piling should be cut off at least 1-foot below the mudline.

18. Hand excavation of sediment (with divers in subtidal areas) is needed to gain access for cutting equipment. To minimize turbidity and releases to the water column and surrounding sediments, hydraulic jetting devices shall not be used to move sediment away from piling.

19. As a condition of their permit, the permittee will be required to provide a post-construction drawing/map to the Corps of Engineers for the Administrative Record, which shows the location and number of piling left in place (above and below mudline) with the global positioning system (GPS) location(s) in NAD 83. The permittee will also be required to provide this information to the property owner(s).

<u>Additional Pile Cutting BMPs for Locations with Contaminated Sediments:</u>

- Complete removal of piling from the environment is preferred. When necessary, project-specific requirements (including equipment selection) for cutting shall be set by the project engineer, and coordinated with EPA and any other appropriate resource agencies, considering the mudline elevation, slope and stability of the site and the condition of the piling.

- If cutting is required, the appropriate depth below mudline for cutting should be made on a project-specific basis, with the goal of minimizing both the resuspension of contaminated sediments and release of wood treatment chemicals.

- For projects with derelict treated pile stubs which can't be removed, consideration should be given to either leaving these in place or, if possible, cutting them below the mudline. Cutting the pile at the mudline may release PAHs into the water column. If a sand cover is placed over the cut pile this may help contain the PAHs, however the new sediment may move over time and the pile may be exposed again.

- The decision to leave piling in place that were originally slated for removal must be coordinated with EPA and any other appropriate resource agencies. For example, if the work is being performed as part of a State or Federal cleanup, the decision to leave piling in place, as well as documentation, must be coordinated with the agency with cleanup oversight.

<u>Piling Removal - Debris Control BMPs</u>

The following BMPs apply to all piling removal activities regardless of the extraction/cutting technique:

20. All work should be confined to within a floating containment boom. The need for, type and size of the boom should be determined on a project-specific basis considering project size, habitat, water flow conditions, sediment quality, etc. A description of boom placement and management must be included in the permit application. A small boat should be available at all times during active construction to manage the boom and captured debris. If used, anchors must be removed once the project is complete.

21. For projects removing treated wood piling or a pier with wood components (like decking), a floating boom with absorbent pads must be installed to capture floating surface debris and any creosote sheen.

    a) The boom shall be located at a sufficient distance from all sides of the structure or piling that are being removed to ensure that contaminated materials are captured.

    b) Extracted piles shall be transferred to the containment basin without leaving the boomed area to prevent loss of treated wood chemicals (e.g., creosote) and debris to the water column and sediments.

    c) The boom shall stay in its original location until any sheen present from removed piling has been absorbed by the boom or removed utilizing absorbent material.

22. Any shavings, sawdust, woody debris (splintered wood, fragments, loose piling) on the water or sediment surface must be retrieved and placed in the containment area. Likewise any pile-associated sediment and adhered organisms must be collected daily, contained on site, and ultimately disposed at an approved upland disposal site along with the extracted piling and decking.

23. When asphalt or other decking is removed, the contractor shall prevent asphalt grit or other debris on the pier from entering the water. Prior to demolition, the contractor shall remove as much of the surface asphalt grit and debris as possible. Floating platforms, suspended tarps, or other means should be deployed under and around the structure to capture grit and debris.

<u>Piling Removal - Piling Storage, Handling and Disposal BMPs</u>

The following BMPs apply to all piling and associated piling-derived debris.

24. Upon removal from the substrate, the piling and associated sediments shall be moved expeditiously from the water into a containment area on the barge deck, adjacent pier, or upland area.

25. The containment area shall be constructed in such a fashion as to restrict any release of contaminants or debris to the aquatic environment. Containment areas on barges, piers and upland areas shall have continuous sidewalls and controls as necessary (e.g., straw bales, oil absorbent boom, ecology blocks, durable plastic sheeting or lining, covers, etc.) to contain all sediment, wood-treating compounds, organisms and debris, and to prevent re-entry of these materials into the aquatic environment.

26. Any floating debris, splintered wood, or sediment removed during pile pulling must be placed in a containment area.

27. Any sediments, construction debris/residue and plastic sheeting from the containment basin shall be removed and disposed in accordance with applicable federal and state regulations. For disposal, this will require shipment to an approved Subtitle D Landfill.

Additional Pile Storage, Handling and Disposal BMPs for Locations with Contaminated Sediments:

- Pre-project planning shall include measures to minimize water contact with piling and associated contaminated sediments. For example, the containment area can be designed to be covered during precipitation and when not in use, and/or piling and associated sediment can be quickly moved to a final disposal location and not retained at the project site.

- Water collected in a containment area may require special management or treatment depending on project specifics. In some cases, water may be stored in Baker tanks and treated off site. In others, a treatment system may be constructed on site. Discharge water must meet the requirements of the Clean Water Act, including the requirements of a National Pollution Discharge and Elimination System permit (or substantive requirements) in order to discharge to surface water.

Piling Placement - Piling Material BMPs

28. Piling may be made of steel, concrete, plastic, treated or untreated wood. For large structural replacements, EPA encourages installation of piling made of concrete, steel, or plastic.

29. If treated wood is used, piling must be treated with wood preservatives in compliance with the Registration Documents issued by EPA under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), and following the Western Wood Preservers Institute (WWPI) guidelines and BMPs to minimize the preservative migrating from treated wood into aquatic environments (see http://www.wwpinstitute.org/documents/BMP_Revise_4.3.12.pdf). Rub strips are required if treated wood is to be used for fender piling.

Piling Placement – General BMPs

30. Wood, concrete, steel or plastic piling may be installed using vibratory methods and/or an impact hammer. Vibratory methods are typically preferred as they reduce impacts to fish listed under the ESA, though this method may be combined with impact hammer for proofing. At the design phase, it is recommended that the applicant contact the USFWS and NMFS to request technical assistance on conservation measures that could be incorporated into the project to minimize impacts to listed species.

31. Hydraulic jetting devices shall not be used to place piling.

32. When a pile is being repaired using splicing or other methods, the permittee shall prevent the introduction of construction-related materials into the aquatic environment. For example, wet concrete must be prevented from entering waters of the state, and forms/sleeves made of impervious materials must remain in place until concrete is cured. Additionally, when a maintenance or repair method requires cleaning of piling, e.g. removal of encrusting organisms, any removed material must be captured and disposed upland.

33. When steel or plastic piling are being reused in the aquatic environment, any sediment adhered to piling or remaining inside of hollow piling must first be removed and disposed of upland at an appropriate location. Creosote-treated piling may not be reused.

34. When proposing to reuse piling, the applicant must evaluate whether there is the potential to transport invasive species from the source area, and must ensure their complete removal such that there is no opportunity for transport/transfer of invasive species. For more information on areas of concern for the spread of invasive species and procedures for minimizing the spread of invasive species through de-contamination see: http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html.

<u>Pile driving with an impact hammer</u>. When using an impact hammer to drive or proof steel piles, one of the following sound attenuation methods must be used:

- Completely isolate the pile from flowing water by dewatering the area around the pile.
- If water velocity is 1.6 feet per second or less, surround the piling being driven by a confined or unconfined bubble curtain (Wursig et al. 2000; Longmuir and Lively 2001) that will distribute small air bubbles around 100 percent of the piling perimeter for the full depth of the water column.
- If water velocity is greater than 1.6 feet per second, surround the piling being driven by a confined bubble curtain (e.g., a bubble ring surrounded by a fabric or non-metallic sleeve) that will distribute air bubbles around 100 percent of the piling perimeter for the full depth of the water column.

Recommended measures for protection of Pacific lamprey ammocoetes in sediment (USFWS 2010a):

- Survey using electrofishing methods outlined in USFWS 2010a Attachment A to determine whether ammocoetes occupy the area, preferably at the project planning stage and when the project is implemented.

- Identify areas adjacent to ammocoete habitat outside of the disturbance area but within the channel and dig holes (e.g., a few scoops with a backhoe) where ammocoetes may take refuge as dewatering occurs. Cover these 'refuge' holes to protect them from predators.

- Dewater slowly over several days or at a minimum overnight. Ramping flows, particularly during hours of darkness, can be effective in encouraging ammocoetes to move out of areas of impact.

- Try an experimental technique – there is some evidence to suggest that if straw bales are placed in habitats where ammocoetes are present, they will move into the straw as dewatering occurs and can be safely removed the next day. If successful, document and provide this information to USFWS.

2.5.2 Dredging

2.5.2.1 Sediment Dispersion Control Methods and Equipment

All dredges cause some re-suspension of sediment. The amount is generally less than 1 percent of the mass of sediment removed, and re-suspension can be controlled (Palermo 2005). Water-borne transport of re-suspended contaminated sediment released during dredging often can be reduced by using physical barriers around the dredging operation area, mechanical control techniques on the dredge equipment, and implementation of BMPs.

Physical Barriers

Two of the more common approaches of physical barriers include silt curtains and sheet pile walls although several other designs are available that have been proven effective. Silt curtains are floating barriers designed to control the dispersion of sediment in a body of water. They are made of impervious flexible materials such as polyester-reinforced thermoplastic (vinyl) and coated nylon. The effectiveness of silt curtains is primarily determined by the hydrodynamic conditions in a specific location. Under ideal conditions, turbidity levels in the water column outside the curtain can be as much as 80 to 90 percent lower than the levels inside or upstream of the curtain (Francingues and Palermo 2005). Conditions that may reduce the effectiveness of these and other types of barriers include significant currents, high winds, changing water levels, and current direction (i.e., tidal fluctuation), excessive wave height, and drifting ice and debris (EPA 2005). Silt curtains are generally more effective in relatively shallow (<10 feet), quiescent water, as water depth and turbulence due to currents and waves increase, it becomes more difficult to effectively isolate the dredging operation from the ambient water.

The use of silt curtains is not expected to be effective in the main channel of the Study Area during dredging operations due to the presence of significant currents, tidal fluctuations, and large debris. Consideration has been given to the use of silt curtains at off-channel areas (coves, embayments, slips, and lagoons) where the water velocities are much lower. In areas with working ship traffic, this approach would require developing a method for quickly removing and reinstalling the silt curtain during barge unloading operations. Silt curtains are retained for further consideration during remedial design.

Sheet piling consists of a series of panels and piling with interlocking connections driven into the subsurface with impact or vibratory hammers to form an impermeable barrier. While the sheets can be made from a variety of materials, such as steel, vinyl, plastic, wood, recast concrete, and fiberglass, lightweight materials (plastic, fiberglass, vinyl) are typically surface mounted to the piling.

Sheet pile containment structures are more likely to provide reliable containment of re-suspended sediment than silt curtains, although at significantly higher cost and with different technological limitations. Sheeting and/or piling must be imbedded sufficiently deep into the subsurface to ensure that the sheet pile structure will withstand hydraulic forces (such as waves and currents) and the weight of material (if any) piled behind the sheeting. Sheet pile containment may increase the potential for scour around the outside of the containment area and sediment re-suspension may occur during placement and removal of the structures. The use of sheet piling may significantly change the carrying capacity of a stream or river and make it temporarily more susceptible to flooding (EPA 2005). Sheet piling may be used in localized areas to prevent migration of highly contaminated sediment during dredging or during disposal operations. Sheet piling is retained for further consideration during remedial design.

Mechanical Control Techniques

Mechanical control techniques are available for mechanical and hydraulic dredges, as well as backhoes. Because conditions vary greatly throughout the study area, these equipment modifications are not considered standard practice and will be used where environmental conditions in the study area dictate the need for them.

Conventional mechanical dredging equipment, such as dredges that use a clamshell bucket, bucket ladder, or dipper and dragline, are ineffective for environmental dredging (Interstate Technology & Regulatory Council [ITRC] 2014). The closed or environmental bucket is a specially constructed dredging bucket designed to reduce or eliminate increased turbidity of suspended solids from entering a waterway. Clamshell dredge buckets can also be fitted with baffles and seals to slow the movement of contaminated water and sediment. USACE used this type of seal, which is similar to a rubber gasket, at the Fox River and Green Bay sites to minimize leakage of PCB-contaminated water and sediment from the bucket.

Additional modifications to conventional mechanical dredging equipment based on site-specific conditions include (ITRC 2014):

- Fitting the crane with longer boom (arm) for additional reach during dredging
- Fitting an excavator with a longer arm for better access
- Using a fixed arm bucket instead of a cable suspended bucket to increase the accuracy and precision of cuts and provide greater bucket penetration in stiffer materials
- Equipping the bucket with hydraulically operated closure arms to reduce bucket leakage
- Installing a sediment dewatering and water collection and treatment facility on the barge or at a temporary staging site
- Installing GPS and bucket monitoring equipment to the dredge to provide the equipment operator with precise coordinate control of the bucket during dredging operations

Recent developments in hydraulic dredging equipment have typically included project- or site-specific modifications in order to achieve the following objectives (ITRC 2014):

- Increase solids content in the dredged material and lower water content
- Prevent debris from entering the auger or pump intake
- Pump dredged material over greater heights or distances
- Improve on shore dewatering of dredged material
- Reduce potential for releasing dredged sediment into the water column

Backhoes can be modified or equipped with covers for the bucket to improve retention of the sediment and to minimize re-suspension.

Other control technologies include:

- Pneuma pump. The Pneuma pump is used primarily for removal of fine-grained sediment and offers high solids concentration (up to 90 percent) in the dredge slurry, with minimal turbidity.
- Large capacity dredges. Larger than normal dredges designed to carry larger loads. This allows less traffic and fewer dumps, thereby providing less disturbance at a disposal site.
- Precision dredging. Dredging utilizing special tools and techniques to restrict the material dredged to that specifically identified. This may mean thin layers, either surficial or imbedded, or specific boundaries.

2.5.2.2 Best Management Practices for Dredge Operations

BMPs or operator-control techniques are important in preventing re-suspension of contaminated sediment. Different types of dredges require different operating practices to control sediment re-suspension. For any dredging operation, sediment re-suspension should be monitored and operations halted if needed to avoid excessive re-suspension of sediment. Examples of BMPs for different types of dredges include (ITRC 2014):

- Operators of bucket dredges can: 1) slow the dredge cycle time, which reduces the velocity of the bucket hitting the river bottom; 2) eliminate multiple bites (the practice of "multiple bites" involves repetitive lowering, raising, and reopening the bucket to obtain a fuller sediment load); 3) avoid stockpiling of silty dredge material on the river bottom; 4) rinse the bucket at the barge to clean off excess sediment between loads; and 5) briefly stop the bucket at the waterline to allow excess water to drain before raising the bucket from the water.

- Operators of cutter head dredges can: 1) reduce rotation speed of the cutter head; 2) reduce the cutter head swing speed so the dredge does not move through the cut faster than it can hydraulically pump the sediment; 3) increase pump rates to provide more suction; 4) operate just below the sediment surface to avoid exposed blades or too deep cutting; and 5) avoid bank undercutting by removing sediment in lifts that are less than or equal to 80 percent of cutter head diameter to reduce cave-ins and sloughing of sediment.

- Operators of hopper dredges can: 1) reduce production rates to eliminate overflow of suspended sediments from the hoppers and 2) reduce the fill level of the hoppers to avoid accidental overflow in rough water.

As described in Fuglevand and Webb (2012), when dredging with an environmental mechanical dredge using an enclosed bucket, each bucket of material placed in the barge contains a portion of sediment and a portion of water because water is not allowed to drain from the bucket. Failure to manage the water in the barge during dredging can result in the release of turbid water back into the dredged area with the potential for increased sediment re-suspension and release and additional generated residuals. The active removal (pumping) and collection of water from sediment barges during dredging prevents the release of turbid water and can lessen sediment re-suspension and contaminant releases. The approach eliminates overflow from the sediment barges and has been successfully incorporated as a BMP at large-scale removals in Puget Sound (AMEC Environment & Infrastructure, Inc. [AMEC] 2013). The purpose of the BMP is to limit release of sediment and associated contaminants back into the waterway from the sediment barge. The findings from a case study of mechanical dredging document that barge overflow can represent a significant contribution to the formation of a residual layer of sediment (Dalton Olmsted & Fuglevand Inc. 2006) and can directly impact water quality and create a risk for offsite contamination.

Implementation of this BMP can include activities such as pumping of the excess water from the sediment barges during dredging, thereby limiting the amount of ponded water within the barge and preventing direct overflow from the barge back to the waterway. Removed water is pumped to a water management system designed to remove excess sediment and chemicals of concern prior to discharge of the water back to the waterway as dredging return water. With proper capture and management, the turbid water placed in a barge by the enclosed dredging bucket can be processed to remove suspended sediment and chemicals of concern that would otherwise be released back into the waterway causing releases (Fuglevand and Webb 2012).

2.5.2.2.1 General Dredge Operations for all Dredging Types

- An appropriate dredge sequencing strategy should be developed to minimize sediment with higher contamination levels from dispersing into adjacent areas.
- Experienced dredge operators should generally be used for dredging activities.
- Contractor vessel draft and movement should be done carefully within dredge areas during construction to limit the potential for scour.
- The potential for scour during construction should be managed to the extent practicable through careful movement of contractor vessel draft, and movement should be performed carefully within dredge areas during construction to limit the potential for scour.
- The location of material removal should be confirmed using a GPS or similar device.
- Any sediment dewater generated should be either released pursuant to applicable discharge requirements, although SMA-specific cases may be identified where elutriate should not be released to surface waters.

2.5.2.2.2 Mechanical Dredge Methods

- Bottom or beach stockpiling should be avoided.
- Taking multiple bites with the clamshell bucket should be avoided under most situations.
- Overfilling of the bucket should be avoided.
- The details of water quality monitoring will vary with SMA-specific water quality certificates or equivalent. A typical approach is that if an exceedance of water quality criteria (as defined by the SMA-specific water quality certification or equivalent) is detected during mechanical dredging, a sequence of responses will be initiated, including implementation of additional controls to be determined as needed. The details and sequence of the steps will be developed and presented during remedial design. Based on recent studies as discussed in the FS, operational controls (as opposed to a silt curtain or similar device) are considered the most effective measures for control of turbidity and contaminant dispersion

during dredging. Examples of possible operational controls that could be implemented on specific mechanical dredging projects as determined in remedial design include the following:

- Reduce the velocity of the ascending loaded bucket through the water column, which reduces the potential to wash sediment from the bucket and reduces the sediment loading into the water column over a set period of time.
- Pause the bucket at the bottom before hoisting the bucket through the water column to allow any overage to settle near the bottom.
- Close the bucket slowly on the bottom.
- Reduce the amount of material in each bucket load.
- Confirm that all the material has been placed into the barge from the bucket before returning the bucket to the water to take another bite of material.
- Use closed or environmental bucket. This technology consists of specially constructed dredging buckets designed to reduce or eliminate increased turbidity from suspended solids from entering the water. Environmental buckets are not suitable in certain situations, including situations with sediments of medium or greater density or in areas with substantial debris which can prevent the bucket from closing properly. If not properly used, closed buckets can exacerbate sediment resuspension in some situations.
- Requiring a debris sweep prior to dredging in known debris areas (debris caught in dredging equipment can cause additional resuspension and release of contaminated sediments).
- Properly selecting the dredge bucket for site conditions (i.e., soft sediment versus debris and/or hard digging).
- Minimizing the potential for slope failures by maintaining stable side slopes during dredging (e.g., shallow top-to-bottom cuts).
- Slowing the rate of dredge bucket descent and retrieval (increasing dredge cycle time).
- Limiting operations during relatively high water velocity conditions (turbulence in the vicinity of the dredge bucket during high-flow conditions can cause additional resuspension and release of contaminated sediments).

- Preventing "sweeping" or leveling by pushing bottom sediments around with dredge equipment to achieve required elevations.
- Preventing interim stockpiling of dredge material.

2.5.2.2.3 Hydraulic Dredge Methods

- During hydraulic dredging, the cutterhead should in most instances be maintained in the substrate and not be raised more than 3 feet above the river bottom when the dredge pumps are running to minimize entrainment of fish.

- As mentioned above for mechanical dredging, the details of water quality monitoring will vary with SMA-specific water quality certificates or equivalent. A typical approach is that if an exceedance of water quality criteria is detected during hydraulic dredging, a sequence of responses should be initiated, including implementation of additional controls to be determined as needed. The details and sequence of the steps should be developed and presented during remedial design. As discussed in the FS, based on recent studies, operational controls (as opposed to a silt curtain or similar devices) are considered the most effective measure for control of turbidity and contaminant dispersion during dredging. Examples of possible operational responses that could be implemented if water quality criteria are exceeded on specific hydraulic dredging projects as determined in remedial design include the following:

    - Reduce cutterhead rotation speed. Reducing cutterhead rotation speed reduces the potential for side casting the excavated sediment away from the suction entrance and resuspending sediment.

    - Reduce swing speed. Reducing the swing speed ensures that the dredge head does not move through the cut faster than it can hydraulically pump the sediment. Reducing swing speed reduces the volume of resuspended sediment. The goal is to swing the dredge head at a speed that allows as much of the disturbed sediment as possible to be immediately removed with the hydraulic flow. Typical swing speeds are 5 to 30 feet/minute.

    - Eliminate bank undercutting. Removing sediment in maximum lifts equal to 80 percent or less of the cutterhead diameter reduces potential for side sloughing.

2.5.3 Placement of Materials for Capping, In-Situ Treatment, and EMNR

2.5.3.1 Residuals

Residuals refer to contaminated sediments remaining in or adjacent to the footprint after dredging is completed (Palermo et al. 2008). Recent field analyses at other sites have shown that the mass of contaminants released during dredging is typically 1 percent of the total contaminant mass removed if the dredge residuals are capped soon after dredging and if dredging BMPs are implemented (USACE 2013).

- Cap residuals soon after dredging limits release of contaminants. This is best accomplished with a 6- to 12-inch layer of sand applied over the dredge area as soon as possible (i.e., promptly after the design dredge elevation has been met in greater than or equal to 95 percent of the dredging work area).

- Sediment cores are assumed to be taken through the post-dredge thin sand layer to confirm that the required layer of sand has been applied to manage residuals. These cores will be taken once the thin sand layers have been applied.

- A 12-inch sand layer is assumed for all dredge areas once 95 percent of dredging is complete in an area to control residuals and releases.

- In areas where PTW is present, 5 percent activated carbon is assumed to be mixed with the residual layer.

- Erosion control measures are assumed to either divert surface water flows/runoff around and away from excavations or limit offsite transport of eroded riverbank materials.
    - Sheet piles can be used to isolate ongoing excavations from erosive hydrodynamic forces if river stage increases during excavation.
    - Permeable berms (e.g., straw waddles) can be used if sheet piles are not feasible.

2.5.3.2 Resuspension

Current velocities greater than 2.5 feet per second may limit the implementability and effectiveness of silt curtain controls, thereby increasing contaminant release rates/mass being transported away from the in-water work area during dredging activities (Palermo et al. 2008). However, dredging is assumed to occur during the approved in-water work window when river currents are low.

- Silt curtains are assumed to be feasible in current velocities less than 2.5 feet per second. Silt curtains are assumed in water depths less than 50 feet and in areas where NAPL is not present.

- A combination of silt and bubble curtains were unable to prevent multiple water quality criteria exceedances downstream of the 2005 Gasco removal action involving NAPL (Parametrix 2006). It is likely that the presence of NAPL contributed to the observed water quality exceedances.

- Engineered rigid control measures (such as sheet piles) may minimize NAPL and sediment releases outside of the sheet pile enclosed work area. These measures will be incorporated into any remediation alternative involving the presence of NAPL.

- As evidenced by recent environmental dredging projects in the Pacific Northwest, dredging BMPs can greatly lessen contaminated sediment releases, residuals, and resuspension. The following BMPs have been effectively used at the Boeing Plant 2 portion of the Lower Duwamish Waterway Superfund Site (adapted from AMEC at al. 2012) and are assumed to be implemented at the Portland Harbor Site:
    - Develop an accurate digital terrain model of sediment contamination depth.
    - Develop a dredging plan, including over-dredge allowance, which will remove the targeted material in a single dredging event.
    - Dredge each SMA to the required depth, verify with bathymetric surveys, and cover with a thin sand residuals layer.
    - Ensure accurate bucket placement by using global positioning systems with sub-foot accuracy.
    - Use stair-step dredge cuts to reduce sediment sloughing along steeper slopes.

2.5.3.3 In-place Avoidance and Minimization Measures

- The placement of material should generally occur starting at lower elevations and working to higher elevations.
- Set volume, tonnage, lead line measurements, and bathymetry information or similar should be used to confirm adequate coverage during and following material placement.
- Imported materials should consist of clean, granular material free of roots, organic material, contaminants, and all other deleterious material.
- If an exceedance of water quality criteria is detected during any type of in-place technology construction activity, a sequence of responses should be initiated according to an SMA-specific water quality certification, or equivalent, including implementation of additional controls to be determined as needed. The details and sequence of the steps should be developed and presented during remedial design. As with dredging, operational controls (as opposed to a silt curtain or similar device) are considered the most effective measure for control of turbidity during placement of material. Examples of possible operational controls that could be implemented during placement of material, as determined during remedial design, are provided below:
    - Placement activities should be progressively slowed until turbidity exceedances are no longer detected outside of the compliance boundary to

minimize sediment suspension. This is similar to the measure of decreasing dredging cycle times to decrease turbidity plumes until the suspended sediment settles.

- Following slowing of capping activities, monitoring should continue, and operations should be modified in this manner as indicated in the terms of the SMA-specific certification or equivalent.

2.5.4 Restoration Measures following Dredging and Capping

- Following dredging in shallow water areas (0 to 20 feet from ordinary low water), backfill would be used to restore the existing (pre-dredging) elevation to avoid loss of shallow water habitat.

- Following dredging and capping in shallow water areas, slope would be restored to 5H:1V where possible.

- Following soil removal on riverbanks, riverbank slopes would be restored to less than 5H:1V where possible.

- Capping in shallow areas would require dredging of an equivalent cap thickness (maximum of 3 feet) prior to placement to allow for a net zero bathymetry change and avoid loss of shallow water habitat.

- Engineered beach mix layer consisting of rounded gravel typically 2.5 inches or less would be applied to the uppermost layer of all caps and dredge leave surfaces in nearshore areas. This layer would provide appropriate substrate habitat for colonization by benthic organisms. Beach mix would not be applied to leave surfaces consisting of sand unless required due to changes in hydrodynamic conditions following remedial activities. In addition, if beach mix is placed over riprap armoring, monitoring would be required to determine whether the site-specific conditions are conducive to maintaining the beach mix habitat layer over the riprap. If monitoring or site specific modeling demonstrates that a sand/gravel surface can be maintained long term, this may be considered by NMFS and EPA when determining the appropriate compensatory mitigation.

- Vegetation would be incorporated into caps placed on riverbanks where possible such as in off-channel areas that are not prone to erosion and with slopes less than 1.7H:1V.

2.5.5 Transport and Offloading of Contaminated Sediments from Barge to Truck

- Standard barge loading controls should be observed to allow for safe movement of the barge and its material on its planned route.

- Where appropriate, a bin-barge or flat-deck barge with watertight sideboards and cover, or other similar measures, should be used to enclose dredged material, including dredged sediment and water, to prevent material from leaking from the bins or overtop the walls of the barge to the extent practicable.

- Improvements at the transload facility will include paving and sealing existing joints and transitions in the roadway. Extruded asphalt curbing will be installed to corral precipitation and add a redundant mechanism to isolate potential spillage in the transloading process.

- Ecology blocks will be used to develop the drying agent containment area within reach of the load-out excavator. The drying agent will be stockpiled on both the barge and the ground adjacent to the excavator.

- A custom fully-welded, watertight steel fabricated box will facilitate a large target for the clamshell dredge to transfer the sediments for rehandle to on-highway 8-axle truck and trailers. The walls of the box will be of sufficient height to eliminate the potential of splattering sediment outside of the containment as the clamshell opens.

- Prior to load-out in the trucks, each bed will be fully lined with plastic before the sediments are loaded. Concurrently, bed liners will be shipped/stored, the lining and truck bed covering stations will be constructed and the truck haul routes (temporary pavement markers) will be established. Upon completion of loading the trucks, each truck bed will be covered prior to departure to the landfill. If sediment spillage occurs at the transfer point, the material will be immediately hand-shoveled, swept up, and incorporated into the load.

- “Trucks entering and leaving" signs will be installed on both sides of the road accessing the facility to establish notice to the public.

- Dust suppression will be handled with water misting of the sediment. A widespread water misting system will be strategically placed to moisten the exposed sediments and completely eliminate airborne particulates. In addition, dust will be fully suppressed at the surge/transload box by water misting. All water used for dust suppression will be contained within the barge.

- The truck loading procedure will be as follows:

    - Truck beds will be lined at the bed lining station.

    - Trucks will pull into the loading zone.

    - Sediments will be placed in the surge/transload box.

  - o An excavator will supplement and mix the drying agent with the sediment as needed to absorb any moisture prior to loading in the truck.
  - o Trucks will be loaded with special care to direct the material for transport to the landfill. On-board axle scales will facilitate loads to legal limits.
  - o The loaded truck will be inspected for any latent spillage of sediment and immediately cleaned off.
  - o The loaded truck will then move to the tarping station for load coverage prior to disembarking to the landfill.
  - o Concurrently with the offload of sediment, submersible pumps will be available to pump off any free liquids generated in the process either in the transport barges or surge box. Water generated will be allowed to settle and the water will be pumped off to a water hauler for disposal at an approved municipal treatment site or the landfill. During pumping operations all connections will be visually monitored for signs of leakage.
  - o Housekeeping is imperative and personnel will be dedicated to maintain drip pans, haul routes, and truck decontamination through the entire cycle of operations.
- As a precaution, two Baker/Frak tanks will be permanently stationed at the facility to facilitate free liquids (if any) pumped off of the sediment transport barges. During pumping operations all connections will be visually monitored for signs of leakage.

2.5.6 Construction of a CDF

Avoidance and minimization measures and BMPs described above for dredging (Section 2.5.2) and placement of materials (Section 2.5.3) would be implemented during construction of the CDF berm to minimize the potential for increased suspended sediment and turbidity levels.

After the berm is built, the CDF area would be enclosed from the river such that there would be no in-water work and no potential for impacts related to turbidity. CDF fill rates will be controlled (and slowed as needed) to prevent berm overtopping. During filling, as water within the CDF begins to approach a level at which discharge is necessary, water quality within the CDF would be sampled prior to discharge to confirm that water quality criteria will be achieved at the compliance boundary outside of the CDF to be established in the NMFS BO and CWA Section 401 Water Quality Certification for the project.

2.5.7 Monitoring

Monitoring is an integral component that will be conducted to evaluate short-term and long-term effectiveness and whether the proposed action is meeting the remedial goals.

The monitoring program will include sediment, surface water, pore water, and fish tissue samples collected at the following frequencies:

- Remedial baseline monitoring will be conducted prior to implementation of remedial activities to gage the performance of the remedy.
- Short-term remedial monitoring will be conducted every 2 years during implementation of remedial measures.
- Performance monitoring will commence the year following completion of remedy implementation and take place every 2 to 3 years for the first 10 years and once every 5 years thereafter.

2.5.7.1 Release

Release is the mechanism by which dredging or capping operations result in the transfer of contaminants from sediment pore water and sediment particles into the water column or air (USACE 2008). Monitoring of water quality parameters will be conducted until applicable passing criteria are achieved. Monitoring may result in actions to address water quality exceedances (such as increased dredge cycle times if water quality exceedances are resulting from dredging activities).

2.5.7.2 Structures

Pilings, docks, berthing or mooring dolphins, and other structures servicing active wharfs or shore-based facilities likely will remain intact during removal activities. To the extent practicable, a fixed arm environmental bucket dredge or excavator is assumed for removal of contaminated sediments and riverbank materials located beneath and around these structures.

Other structures (such as dilapidated, obsolete, or temporary structures) will be removed prior to environmental dredging or excavation activities. All structures with foundations in contaminated sediments or riverbank materials, and not servicing active wharfs or shore-based facilities, will be removed prior to dredging or excavation. Removal of these structures will incorporate water quality controls and monitoring to prevent the offsite transport of contaminated sediments, as described above.

2.5.7.3 Enhanced Monitored Natural Recovery

EMNR is accomplished through the placement of a 12-inch layer of sand, which is sufficient to allow for mixing with the underlying sediment bed while also retaining clean sand above the mixed interval. In areas where PTW is present, 5 percent activated carbon is added to the sand layer.

Monitoring is an integral component of EMNR and will be conducted to evaluate long-term effectiveness. The monitoring program will include sediment, surface water, pore water, and fish tissue samples collected at the frequencies listed in Section 2.5.7 above.

2.5.7.4 Monitored Natural Recovery Long-term Monitoring

Monitoring of MNR areas may include biota tissue sampling and analysis (including resident fish species only), surface sediment sampling, and surface water sampling. Likely avoidance and minimization measures for long-term monitoring activities include the following:

- All biota collection activities should be conducted according to a field sampling plan and standard operating procedures (SOPs), or equivalent, similar to those used to guide sample collection activities for the RI.
- Biota sampling will be scheduled to occur during fish windows to avoid impacts on ESA-listed species. However, it is still possible that listed species could be captured during biota sampling activities.
- Fish capture activities should be done carefully and in a way that targets the intended species, to the extent possible. If non-target species are captured, they should be returned to the river as quickly as possible.
- Boat and backpack electrofishing activities should be conducted by field staff appropriately trained for using electrofishing equipment.
- Surface sediment sample collection, processing, equipment decontamination, and disposal of waste activities should be conducted according to the field sampling plan and SOPs, or equivalent, similar to those used to guide sample collection activities for the RI.
- Surface sediment sample locations should be targeted and confirmed using a differential global positioning system with appropriate corrections and offsets for horizontal and vertical control.
- Surface water sample collection, processing, and equipment decontamination activities also should be conducted according to the field sampling plan and SOPs, or equivalent, similar to those used to guide sample collection activities for the RI.
- Care should be taken to not disturb the sediment surface during surface water sample collection.

2.5.8 Institutional Controls

ICs that prevent or limit exposure to contaminants and maintain containment integrity of caps on both a short- and long-term basis are proposed as a component of the proposed action.

2.5.8.1 Fish Consumption Advisories

- Fish consumption advisories would be required until such time as RAO 2 is achieved.
- Outreach would be conducted to educate the public about the fish consumption advisories using informational materials.
- Surveys of fish consumption patterns would be conducted to determine advisory effectiveness.

2.5.8.2 Waterway Use Restrictions or Regulated Navigation Areas (RNAs)

- Where caps will be used to contain contamination, waterway use restrictions or RNAs or other types of use restriction mechanisms may be used to maintain the integrity of the cap.
- This will include prohibiting anchoring of vessels or the use of spuds to stabilize vessels in areas containing caps.
- Notifications, such as signs and buoys, placed by the Oregon Marine Board may be used to warn vessels from the area.
- Periodic inspections of RNA notifications or the use of restriction mechanisms will be needed to ensure they are functional and effective.

2.5.8.3 Land Use/Access Restrictions

Land use or access restrictions may need to be implemented in nearshore areas and riverbanks to maintain the integrity of caps. Depending on who owns the land being remediated, an equitable servitude and easement or some other proprietary control may be used to establish necessary use restrictions. As discussed above, RNAs or another mechanism implemented by the Oregon Department of State Lands (DSL) may be used on publicly owned submerged lands. Monitoring, including inspections, will be needed to ensure that restrictions are functioning as intended.

2.6 PROJECT SCHEDULE

As described in Section 2.5.1, in-water construction activities for the proposed action would be constructed within the in-water work window from approximately July 1 to October 31 (122 days per year). Dredging is assumed to occur 24 hours per day and 6 days per week. As described in the FS (Section 3.6), based on estimated dredge volumes and production rates, and estimated cap material volumes and application rates, in-water construction activities are estimated to take between 4 to 5 years to complete. As described in Section 4 of the FS, it is anticipated that it will take several years of MNR to reach RAOs across the Site.

2.7 ACTION AREA

The proposed action area boundary is defined as the area where remedial activities will occur and the area where impact avoidance and minimization measures, including construction of compensatory mitigation projects pursuant to CWA Section 404, could occur. The action area is shown in **Figure 2-5**.

As described above, remedial activities will occur in the Lower Willamette River from RM 1.9 to 11.8, primarily below the water surface elevation but also including riverbanks in some areas. The action area also includes the portion of the Lower Columbia River downstream from its confluence with the Willamette River to where impacts, such as contaminant exposure from resuspended sediments, could occur during implementation of remedial activities at the Site. Therefore, the action area includes an area downstream to the mouth of the Columbia River where salmonids exposed to contaminants at the Site could occur (and be preyed upon). The action area also includes the potential transport corridor used to move contaminated sediment and soil removed from the Site within the federally authorized navigation channel down the Willamette River to the Columbia River and upstream on the Columbia River to a potential transloading facility. While the locations where compensatory mitigation projects would be constructed have not yet been identified, they may occur in the Lower Willamette River or the Lower Columbia River, preferentially within the same fourth level hydrologic unit watershed as where impacts could occur from the proposed action.

Although the action area is broadly defined here to include the Columbia River as described above, most effects are generally expected to be confined to the area adjacent to the points of dredging, in-place technologies, construction of a CDF, and construction of compensatory mitigation projects.

3.0 PRESENCE/STATUS OF LISTED SPECIES AND/OR DESIGNATED CRITICAL HABITAT IN PROJECT AREA

Several listed species occur within the action area, which includes both the Lower Willamette River and the Lower Columbia River, as described in Section 2.7. This section describes the presence and timing of these species within the various components of the action area. The timing of salmonid species presence is summarized in Figure 3-1.

3.1 CHINOOK SALMON

Lower Columbia River, Upper Willamette River, Upper Columbia River spring-run, Snake River fall-run, and Snake River spring/summer-run Chinook salmon Evolutionarily Significant Units (ESUs) are listed as threatened under the ESA.

Of all the species of Pacific salmon, Chinook salmon display the greatest within-species diversity of habitat use and life history strategies. Variations in life history strategies and habitat use include differences in timing and age of adult return to freshwater and juvenile seaward migration; duration of freshwater, estuarine, and oceanic residency; ocean distribution and migration patterns; and location and elevation of spawning (Schiewe and Kareiva 2001). Differences in expression of life history patterns are the result of geographic and genetic isolation that divides populations into two fundamental forms—stream-type and ocean-type (Healey 1983; Schiewe and Kareiva 2001). Ocean-type populations typically migrate to sea as subyearlings prior to age one, use estuarine and nearshore habitats for extended periods, often spend their entire ocean residence on the continental shelf, and return to their natal stream in the fall immediately before spawning. Stream-type populations generally spend one or more years in freshwater before migrating to sea, undertake extensive offshore migrations, and return to their natal streams during the spring or summer, often holding in freshwater for several months before spawning in late summer (Schiewe and Kareiva 2001). In the Columbia River Basin, each life history strategy is represented by numerous runs (Waples et al. 1991).

An additional, and very specific, form of life history variation in Chinook salmon that is used to categorize populations is adult run-timing. Chinook populations or stocks are typically characterized as “spring-,” “summer-,” or “fall-run,” according to the time adults enter freshwater to begin spawning migration. In general, “spring” Chinook salmon are stream-type fish, and “fall” Chinook salmon are ocean-type fish. “Summer” Chinook have both stream- and ocean-type life history patterns (Waples et al. 1991). Ocean-type spring- and summer-run fish spawn and rear in small, high-elevation streams, whereas ocean-type summer- and fall-run fish spawn and rear in mainstem areas or the lower parts of major tributaries (Waples et al. 1991).

Juvenile Chinook salmon emerging from spawning areas in the Willamette River and Columbia River watershed use the action area for rearing and migration to the ocean. Specific habitat preferences of juvenile Chinook in the Lower Willamette River are poorly understood. Limited radio-telemetry studies of outmigrating yearling juvenile Chinook (stream-type) salmon in the Lower Willamette River did not identify a preference for nearshore versus channel habitat, nor was any particular habitat type (e.g., rock outcropping, beach, and riprap) significantly preferred over another (Friesen et al. 2004). Small subyearlings (ocean-type) are expected to migrate more slowly and feed and rear as they migrate. In general, the literature suggests that juvenile salmon require a variety of habitat types and features in order to grow and survive to adulthood. Small subyearling salmon are known to be most abundant in shallow, low-velocity areas where substrate particle size is small (e.g., sand and gravel) (Bjornn and Reiser 1991; Everest and Chapman 1972).

Little is known about the habitat use of small subyearling Chinook salmon within the action area due to difficulties of applying sampling methods to these small fish. Friesen et al. (2004) captured subyearling Chinook during beach seining in the lower Willamette River; therefore, it is known that they use beach habitats within the Site. In addition, studies have shown that juvenile fish move to faster, deeper water as they grow and use cover as refuge from high velocities and predators (Hillman et al. 1987; Oregon Department of Fish and Wildlife [ODFW] 2005a). Friesen et al. (2007) found that within the Site the influence of shoreline habitat on large (greater than 100 millimeters [mm] fork length) actively migrating Chinook was minimal and that the distribution of telemetry recoveries closely followed the proportional availability of habitat types.

Analysis of stomach contents of juvenile Chinook in the Lower Willamette River indicated they fed mainly on Daphnia and, to a lesser extent, on Corophium (Vile et al. 2004) and other small fishes. Because Daphnia is relatively abundant in the Lower Willamette, this finding suggests juvenile Chinook may prey on what is most prevalent (Friesen et al. 2004). Adult fish are no longer feeding by the time they enter the action area.

3.1.1 Upper Willamette River ESU

The Upper Willamette River Chinook ESU includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, as well as seven hatchery stocks. The Upper Willamette River ESU occurs in both the Lower Willamette River portion of the action area as well as the Lower Columbia River portion of the action area. There is no spawning of this ESU in either the Lower Willamette River or Lower Columbia River portions of the action area.

Numbers of natural-origin spring Chinook salmon in the Willamette River basin are extremely depressed (McElhany et al. 2007). Historically, the spring run of Chinook may have exceeded 300,000 fish (Myers et al. 2006). The current annual abundance of natural-origin fish is less than 10,000, and only two populations (the McKenzie and Clackamas populations) have significant natural production. While counts of hatchery and naturally spawning adult spring Chinook salmon over Willamette Falls since 1946 have increased, approximately 90 percent of the return is now composed of hatchery fish. The majority of the populations in this ESU include very low numbers (less than a few hundred) of naturally spawning fish. For the most part, natural runs have been replaced by hatchery production (NMFS 2008a).

The Upper Willamette River Chinook have been adversely affected by the degradation and loss of up to 40 percent of their spawning and rearing habitat (i.e., loss of 30 to 40 percent) associated with the development of hydropower and flood control projects and the interaction with a large number of natural spawning hatchery fish. Other limiting factors include altered water quality and temperature, lost and degraded floodplain connectivity and lowland stream habitat, and altered stream flow in the tributaries (NMFS 2005a, NMFS 2006a). NMFS (2007) identified degraded floodplain connectivity and function, channel structure and complexity, riparian areas and large wood recruitment, water quality, fish passage, and hatchery impacts as the major factors limiting recovery of this species.

On March 24, 1999, the Upper Willamette River Chinook salmon were listed as a threatened species (NMFS 1999a). This status was reaffirmed on June 28, 2005 (NMFS 2005b).

3.1.1.1 Presence in the Action Area

All Upper Willamette River Chinook salmon migrate through both the Willamette River and Columbia River portions of the action area. Juvenile Upper Willamette River salmon that have emerged from spawning locations in the Upper Willamette River watershed use the lower mainstem Willamette River and Columbia Slough for rearing and as a migratory corridor on their journey to and from the Pacific Ocean.

<u>Lower Willamette River Presence:</u> Both yearling and subyearling age classes of juvenile Chinook are expected to be present within the Site based on the range of sizes of fish collected during the Friesen et al. (2004) study. The investigators in this study found that naturally spawned Chinook ranged in size from fork lengths of approximately 30 mm (subyearling) to over 200 mm (yearling). In the same study, naturally spawned Chinook collected in beach seines showed fork length distributions with peaks at 45 and 75 mm (Friesen et al. 2004). Friesen et al. (2004 and 2007) suggest that this distribution implies that subyearling fish from different spring run subpopulations were present within the Site; however, the smaller juveniles could also be early migrant fall Chinook from the Clackamas River.

Smaller subyearling fish (30 to 70 mm) are a size that are expected to be more shoreline oriented and to spend more time within the Site, whereas the larger subyearling and yearling fish are expected to be found throughout the width of the river and migrate quickly as suggested by a number of studies (Ward et al. 1988, 1994; North et al. 2002; Friesen et al. 2003). Although the smaller subyearlings are expected to spend more time within the Site, the specific residence time of these individuals is not known because the radio telemetry studies conducted to determine this information require insertion of tags into the fish. Due to the large size, the tags are difficult to insert into fish smaller than 100 mm fork length.

The migration rate for juvenile (yearling and large subyearling) Chinook salmon was estimated by Friesen et al. (2004) to range between 5.2 and 7.7 miles/day, with an average residence time of 2.8 days in the Lower Willamette River based on a tagging study. North et al. (2002) found large subyearling Chinook (greater than 107 mm fork length) migrated at a rate of 4.4 miles/day, whereas yearling Chinook migrated at a rate of 6.8 miles/day. Therefore, it is assumed that juvenile yearling and large subyearling Chinook typically spend approximately 2 to 4 days within the lower Willamette River. Small subyearling Chinook are thought to spend longer periods of time at the Site than the larger fish, but the specific length of time for each individual is not known, as described above.

Juvenile Chinook densities tend to increase in November, peaking between January and April, and falling to near zero after June (Friesen et al. 2004). Juvenile Chinook are likely present within the Lower Willamette River in all months of the year due to the presence of both early and late out-migrants. Based on Friesen et al. (2004), very small numbers of Chinook were found in the Site outside of the November through June migration period. The small subyearlings are the fish expected to be present in low numbers outside of the November through June migration period.

Based on fish ladder counts at the Willamette Falls locks and the North Fork Dam on the Clackamas River, returns of spring-run adults are expected to peak in the Lower Willamette River during the spring months (between April and July) when flows are generally high. Fish counts in the Willamette and Clackamas rivers indicate spring-run adults will also be present in lower numbers in March as well as August and September. Reduced abundance of adults in the action area occurs between October and February.

Adult Chinook have been shown to travel through the Columbia River and Willamette systems at rates of approximately 20 to 35 kilometers (km)/day (Keefer et al. 2004). Based on a lack of specific data, it is assumed that adults of all species could spend up to 1 day within the Lower Willamette River portion of the action area and up to 2 days within the Lower Columbia River portion of the action area.

<u>Lower Columbia River Presence:</u> Because of the limited information specific to the Upper Willamette River ESU presence on the Lower Columbia River, juvenile and adult distribution and migration timing of Upper Willamette River Chinook is assumed to be similar to what is described for the Lower Willamette River.

3.1.2 Lower Columbia River ESU

The Lower Columbia River Chinook ESU includes all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries upstream to Hood River on the Oregon side and the White Salmon River on the Washington side, including a large number of hatchery stocks. This ESU also includes populations from the Willamette River below Willamette Falls, with the exception of Clackamas River spring-run fish, which are listed under the Upper Willamette River ESU (NMFS 2005b). The Lower Columbia River ESU consists of both spring- and fall-run fish and therefore display both ocean-type and stream-type life history patterns.

The Lower Columbia River ESU occurs in both the Lower Willamette River portion of the action area as well as the Lower Columbia River portion of the action area, which includes a stretch of river above the Willamette River confluence. Clackamas fall-run Chinook is the subpopulation from the ESU that occurs in the Lower Willamette River.

Lower Willamette River Status: Fall-run Chinook in the Clackamas River are largely confined to the mainstem below River Mill Dam and the lower reaches of the major tributaries (Deep, Clear, and Eagle creeks) in the lower river (Hatchery Scientific Review Group [HSRG] 2009). Although fall Chinook are native to the Clackamas, and historically probably spawned up through the middle reaches of the Clackamas, they were extirpated in the mid-1930s by poor water quality in the Lower Willamette and the presence of Faraday and River Mill dams that blocked access to historical spawning habitat from 1906 to 1939 (HSRG 2009). The run was re-established using lower Columbia River stocks; however, planting was stopped in the early 1980s, and the population is now supported by natural production of what are believed to be tule Chinook. According to NMFS (2010a, b) and McElhany et al. (2007), there is little reliable abundance data for the Lower Columbia River Clackamas population, and estimates put the population in the "extirpated or nearly so" persistence category based on the minimum abundance threshold.

Lower Columbia River Status: Over the last century, adult returns of Lower Columbia River Chinook have greatly declined. Between 1997 and 2001, an annual return of 7,404 Lower Columbia River Chinook salmon was estimated for populations spawning on the Columbia River upstream of the Willamette River confluence. Long-term trend indicators from 1967 to 2005 for most Lower Columbia River Chinook populations are negative. However, 2001 and 2002 abundance estimates increased for most Lower Columbia River Chinook salmon populations over the previous few years (Good et al. 2005). Lower Columbia River Chinook salmon were listed as threatened on March 24, 1999 (NMFS 1999a). This status was reaffirmed on June 28, 2005 (NMFS 2005b).

3.1.2.1 Presence in the Action Area

Lower Willamette River Presence: As mentioned above for the Upper Willamette River Chinook ESU, both subyearling and yearling juvenile Chinook are expected to be present within the Site. The subyearlings present within the Site could also come from the Lower Columbia River population as well as the Upper Willamette River population due to the fall run timing and the resulting ocean type fish that migrate as subyearlings. As a result, the smaller subyearlings found within the Site could also be from the Lower Columbia River population. Juvenile Chinook densities tend to increase in November, peaking between January and April, and falling to near zero after June (Figure 3-1, Friesen et al. 2004). Juvenile Chinook likely are present within the Lower Willamette River in all months of the year due to the presence of both early and late out-migrants. Based on Friesen et al. (2004), very small numbers of Chinook were found in the Site outside of the November through June migration period. Yearling and larger subyearling Chinook are not known to spend significant amounts of time within the Site, and it is expected that the small subyearlings (30 to 70 mm) spend more time within the Site, although the specific residence time of this size of fish is not known. Juvenile fish from this ESU are expected to be present in low numbers between July and the beginning of November.

Fall-run adults return to spawn generally between August and October (NMFS 2008a). Reduced abundance of adults in the action area occurs during the time period between November and July.

<u>Lower Columbia River Presence:</u> All Lower Columbia River Chinook populations upstream of the Willamette River and the Clackamas River population are expected within the Columbia River portion of the action area.

Adult Lower Columbia River salmon exhibit a bimodal pattern run timing, with some populations returning in the fall and others during the spring. Fall-run adult fish enter the Columbia River generally between August and October, whereas spring-run adult fish enter the Columbia River generally between March and June (NMFS 2008a). Because information regarding the presence and timing of juvenile Lower Columbia River ESU Chinook in the Lower Columbia River is limited, distribution and migration timing of juvenile Lower Columbia River Chinook is assumed to be similar to what is described for the Lower Willamette River. Juvenile fish from this ESU are expected to be present between November and June, with peak occurrence between January and April.

3.1.3 Upper Columbia River Spring-run ESU

The Upper Columbia River spring-run Chinook ESU includes all naturally spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of the Rock Island Dam (RM 453) and downstream of Chief Joseph Dam (RM 545) in Washington (NMFS 2005b) as well as six hatchery stocks. The ESU includes spring-run Chinook from the Wenatchee, Entiat, and Methow drainages. Chinook in the Okanogan River are primarily ocean-type fish and are included in the Upper Columbia River Summer and Fall ESU, which is not listed under the ESA (Good et al. 2005).

Historical abundance data specific for this ESU are unavailable. However, historical estimates of Chinook salmon returning to the Upper and Middle Columbia River are in the hundreds of thousands (Mullan 1987). Abundance of most populations within this ESU declined to extremely low levels in the mid-1990s, increased to levels above (Wenatchee and Methow) or near (Entiat) the recovery abundance thresholds in the early 2000s, and are now at levels intermediate to those of the mid-1990s and early 2000s. 2007 Upper Columbia River spring Chinook jack counts, an indicator of future adult returns, have increased to their highest level since 1977 (NMFS 2008a). Based on 1980 to 2000 returns, the estimated annual population growth rate for this ESU is 0.85 (a growth rate of less than 1.0 is non-viable) (Good et al. 2005). Assuming that population growth rates were to continue at 1980 to 2000 levels, Upper Columbia River spring-run Chinook salmon populations are likely to have very high probabilities of decline within 50 years (87 to 100 percent) (Good et al. 2005), and the species is likely to become extinct.

Major factors limiting the recovery of this species include mortality in the Columbia River hydropower system, tributary riparian habitat degradation and loss of in-river wood, altered tributary floodplain and channel morphology, reduced tributary streamflow and impaired passage, and harvest impacts (NMFS 2007).

Upper Columbia River Chinook were listed as threatened on March 24, 1999 (NMFS 1999a). This status was reaffirmed on June 28, 2005 (NMFS 2005b).

3.1.3.1 Presence in the Action Area

Fish from this ESU pass through the Columbia River portion of the action area as juvenile downstream migrants and adult upstream migrants. No fish from this ESU are expected within the Lower Willamette River portion of the action area. Mean abundance estimates of the returning adult populations of the Entiat, Wenatchee, and Methow rivers from 1997 to 2001 indicate a returning population of 1,260 fish (Good et al. 2005). Spawning is expected to occur in August through September.

Adult spring Chinook return to the lower Columbia River in early spring, peaking in April and May (Upper Columbia Salmon Recovery Board [UCSRB] 2007, Fish Passage Center [FPC] 2012). Reduced abundance of adults in the action area is expected to occur in the time period between June and March. Peak juvenile Chinook migration in the lower Columbia River occurs between April and June. Reduced smolt abundance within the action area is expected between the time period of August to March (DART 2011).

3.1.4 Snake River Fall-run ESU

The ESU includes all naturally spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam, and in the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River, as well as four hatchery stocks (i.e., the Lyons Ferry Hatchery, Fall Chinook Acclimation Ponds Program, Nez Perce Tribal Hatchery, and Oxbow Hatchery fall-run Chinook hatchery programs).

Between 1938 and 1949, the estimated annual return of Snake River Fall-run Chinook was 72,000 fish, and by the 1950s, numbers had declined to an annual average of 29,000 fish. Numbers of Snake River fall-run Chinook salmon continued to decline during the 1960s and 1970s as approximately 80 percent of their historical habitat was eliminated or severely degraded by the construction of the Hells Canyon hydropower complex (1958 to 1967) and the lower Snake River dams (1961 to 1975). Total returns of fall Chinook over Lower Granite Dam increased steadily from the mid-1990s to the present. Natural returns increased at roughly the same rate as hatchery origin returns (through run year 2000); since then hatchery returns have increased disproportionately compared to returns of natural-origin fish (NMFS 2008a).

The average abundance of 1,273 Snake River fall-run Chinook over the most recent 10-year period is below the 3,000 natural spawner average abundance thresholds that the Interior Columbia Technical Recovery Team (ICTRT) identified as a minimum for low risk (NMFS 2008a). Counts of naturally spawning adult Snake River fall-run Chinook salmon at Lower Granite Dam were 1,000 fish in 1975 and ranged from 78 to 905 fish (with an average of 489 fish) over the ensuing 25-year period through 2000 (Good et al. 2005). Between 2001 and 2003, numbers of natural-origin Snake River fall-run Chinook increased, ranging from 2,095 to 3,895 fish. Total hatchery and natural origin adult returns at Lower Granite Dam from 1983 through 2000 ranged from 385 to 3,830 fish. In the most recent 10-year period, total returns at Ice Harbor Dam (Snake RM 9.7) were more than 16,000 fish (DART 2011). Recent adult return data led NMFS to conclude that this ESU is subject to a declining risk of extinction (NMFS 2011a).

NMFS identified mortality in the mainstem lower Snake River and Columbia River hydropower systems, degraded water quality, reduced spawning/rearing habitat due to Snake River hydropower development, and overharvest as the major factors limiting recovery of this species (NMFS 2007).

The Snake River fall-run Chinook was listed as threatened on April 22, 1992 (NMFS 1992). This status was reaffirmed on June 28, 2005 (NMFS 2005b).

3.1.4.1 Presence in the Action Area

Fish from the Snake River Fall ESU use the Lower Columbia River primarily as a migration corridor to and from the ocean. All fish from this ESU travel through the Columbia River portion of the action area. No fish from this ESU are expected within the Lower Willamette River portion of the action area.

Snake River Fall Run Chinook salmon spawning occurs primarily in the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater, Grande Ronde, Salmon, and Tucannon rivers. Adult Snake River fall-run Chinook salmon enter the Columbia River in July and August and migrate into the Snake River from August through October. Spawning generally occurs in the main stem and in the lower reaches of large tributaries from October through November (Waples et al. 1991). Adult fall-run Chinook salmon would be expected to be in the Columbia River portion of the action area in August through October, with the peak moving through in August and September (FPC 2012).

3.1.5 Snake River Spring/Summer-run ESU

The ESU includes all naturally spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins, as well as 15 hatchery stocks.

According to Matthews and Waples (1991), total annual Snake River spring/summer-run Chinook salmon production may have exceeded 1.5 million adult fish in the late 1800s. Total (natural plus hatchery origin) returns fell to roughly 100,000 spawners by the late 1960s (Fulton 1968) and were below 10,000 by 1980. The average returns over the past 10 years are higher, at about 130,630 fish (DART 2011). Abundance has been stable or increasing on average over the last 20 years. In 2007, jack counts (a qualitative indicator of future adult returns) were the second highest on record. However, on average, the natural-origin components of Snake River spring/summer Chinook populations have not replaced themselves (NMFS 2008a).

The NMFS has identified mortality from the mainstem lower Snake River and Columbia River hydropower systems, reduced tributary streamflows, altered tributary channel morphology, excessive sediment in tributaries, degraded tributary water quality, and harvest- and hatchery-related adverse effects as the major factors limiting recovery of this species (NMFS 2007).

On April 22, 1992 this ESU was listed as a threatened species (NMFS 1992). This status was reaffirmed on June 28, 2005 (NMFS 2005b).

3.1.5.1 Presence in the Action Area

Snake River spring/summer-run ESU Chinook salmon use the Columbia River portion of the action area as a migration corridor for both juvenile and adult fish (StreamNet 2011). No fish from this ESU are expected within the Lower Willamette River portion of the action area. Spring/summer-run Chinook return to the Columbia River from March through July, peaking in April, May and June (FPC 2012). Reduced numbers of adults are expected within the action area during the time period of August to February. Spawning occurs in August through September (Good et al. 2005).

Peak juvenile Chinook migration in the Columbia River occurs during April and June. Reduced numbers of juvenile Chinook are expected from August to March (Figure 3-1, DART 2011).

3.2 LOWER COLUMBIA RIVER COHO SALMON

This ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (McElhany et al. 2007). The populations include naturally spawned coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia upstream to and including the Big White Salmon and Hood rivers, and a number of hatchery stocks. The boundaries do not extend into the Upper Willamette portion of the basin because Willamette Falls is a natural barrier to fall migrating salmonids.

This ESU includes two distinct runs: early returning (Type S) and late returning (Type N). Type S coho salmon generally migrate south of the Columbia River once they reach the ocean, returning to freshwater in mid-August and to the spawning tributaries in early September. Spawning peaks from mid-October to early November. Type N coho have a northern distribution in the ocean, return to the Columbia River from late September through December, and enter the tributaries from October through January. Most Type N spawning occurs from November through January, but some spawning occurs in February and as late as March (NMFS 2008a).

Data on the status of Lower Columbia River coho salmon are very limited. In general, wild coho in the Columbia River basin have been in decline for the past 75 years. The number of wild coho returning historically was at least 600,000 fish (Chapman 1986). As recently as 1996, the total return of wild fish may have been as few as 400 fish (Chilcote 1999). Of the 25 historical populations, only the Clackamas and Sandy rivers show direct evidence that coho reproduction is not dependent on the spawning of stray hatchery fish. In the last 5 years, there has been an increase in the abundance of wild coho in the

Clackamas and Sandy rivers (McElhany et al. 2007). In 2002, total Lower Columbia River coho returns to the Clackamas, Sandy, and upper Gorge tributaries were approximately 4,700 fish (Good et al. 2005). More recently, the coho smolt releases from the Eagle Creek hatchery in the Clackamas River basin have increased the returning coho population by 11,200 fish.

On June 28, 2005, Lower Columbia River coho salmon were listed as threatened under the ESA (70 Federal Register No. 123. 37160). NMFS (2007) identified floodplain connectivity and function, degraded channel structure and complexity, degraded riparian areas and large wood recruitment, degraded stream substrate, degraded streamflows, degraded water quality, and harvest and hatchery impacts as the major factors limiting recovery of Lower Columbia River coho salmon.

3.2.1 Presence in the Action Area

All returning adults to the Clackamas River and Columbia River tributaries upstream of the Willamette River confluence pass through the Columbia River portion of the action area. In addition to the Columbia River portion of the action area, all fish returning to the Clackamas River pass through the Lower Willamette River portion of the action area.

<u>Lower Willamette River Presence:</u> Only fish from the Clackamas River use the Lower Willamette River portion of the action area. Returning adults are potentially present from mid-August through March (Weitkamp et al. 1995). Peak adult presence in the Lower Willamette River action area is expected between October and February. Reduced adult abundance within the Lower Willamette River is expected from April to July (Figure 3-1, Portland General Electric [PGE] 2012).

Coho smolts migrate downstream between April and June, peaking in May (Weitkamp et al. 1995). Reduced coho smolt abundance within the Lower Willamette River portion of the action area is expected in the time period of July to March.

<u>Lower Columbia River Presence:</u> According to the StreamNet database (2011), the action area provides both rearing and migration function for Lower Columbia coho. For adults, it is used as a migration corridor through which individuals would pass relatively rapidly to spawning areas. Juveniles also use the mainstem for rearing during some parts of the year (Kostow 1995). Spawning occurs in some of the larger tributaries (e.g., Cowlitz, Coweeman, and Kalama) as well as many of the small drainages. Smaller fry forage mainly on terrestrial and aquatic insects, whereas larger juveniles may also prey upon small fishes, including other salmonids (Sandercock 1991). Specific information on rearing within the mainstem Columbia River is limited, but based on general knowledge of coho life histories, it is likely that the great majority of these fish overwinter outside of the mainstem. Smaller rearing fish may use the shallower waters near the shoreline; however, migrating juveniles are less likely to be nearshore-dependent.

As a general rule, coastal coho salmon enter rivers in October and spawn from November to December and occasionally into January, but adults can enter the Columbia River early (entering in August) or late (spawning in March) (Weitkamp et al. 1995). Peak migration through the Lower Columbia River portion of the action area is expected between October and February (Weitkamp et al. 1995, PGE 2012). Reduced numbers of adults are expected in April to July. Yearling juveniles emigrate from freshwater between early April and mid-June, with peak emigration occurring in the middle of May (Weitkamp et al. 1995). A wide variety of conditions—such as habitat condition, flow control from hydroelectric dams, and nearshore ocean conditions—may affect outmigration timing. Reduced juvenile abundance within the action area is expected from July to March.

3.3 STEELHEAD

Five distinct population segment (DPSs) of steelhead are listed as threatened in the Columbia River Basin, including the Upper Willamette River, Lower Columbia, Upper Columbia, and Snake River steelhead DPSs. All steelhead DPSs pass through the Columbia River portion of the action area on their migrations to and from the Pacific Ocean. Only the Upper Willamette steelhead DPS would be expected to pass through the Lower Willamette portion of the action area.

Adult steelhead may be found in the action area year-round, but the peak of the adult upstream migration generally occurs between mid-January and mid-March and again from the beginning of May to the middle of September (Ellis 1999). Available data suggest that most naturally spawning steelhead populations smolt at 2 years of age (Busby et al. 1996). Most steelhead are anadromous and exhibit similar life histories to stream-type Chinook salmon, with a multi-year freshwater rearing period, followed by oceanic migration and residency for 1 to 2 years, before returning to freshwater to spawn. Unlike the Pacific salmon species, steelhead are iteroparous and may spawn multiple times.

Steelhead can be divided into two basic reproductive ecotypes based on their state of sexual maturity at the time of river entry and the duration of spawning migrations; in the Columbia River Basin, these are often referred to as summer-run and winter-run life histories. Summer-run steelhead enter freshwater in an immature state during the summer of the year preceding spawning, mature over the fall and winter, and spawn the following spring. Winter-run fish enter freshwater as mature adults between late fall and the following spring, spawning shortly thereafter (Good et al. 2005).

3.3.1 Upper Willamette River DPS

The Upper Willamette steelhead DPS includes all naturally spawning populations from the Willamette River and its tributaries upstream of Willamette Falls, up to and including the Callapooia River (NMFS 2006b). Hatchery origin summer-run steelhead within this basin are not included in the DPS.

Historical abundance of Upper Willamette River steelhead is unknown. However, fish census data collected at Willamette Falls indicate a return of approximately 26,000 fish in 1971. Returns fell below 5,000 fish between 1990 and 1999 (Good et al. 2005).

NMFS (2007) identified degraded floodplain connectivity and function, channel structure and complexity, riparian areas and large wood recruitment, streamflow, fish passage, and predation/competition and disease as the major factors limiting recovery of this species.

The Upper Willamette River steelhead DPS was listed as threatened on March 25, 1999 (NMFS 1999b). This status was reaffirmed on January 5, 2006 (NMFS 2006b). The Upper Willamette steelhead DPS consists solely of naturally spawned fish.

3.3.1.1 Presence in the Action Area

All fish from this DPS utilize the Willamette and Columbia River portions of the action area as a migration and rearing corridor. The median migration rate for steelhead is 7.8 miles/day, with an average residence time of 2.5 days (Friesen et al. 2004).

Lower Willamette River Presence: Winter steelhead enter the Willamette River beginning in January and February, but they do not ascend to their spawning areas until late March or April (Dimick and Merryfield 1945, as cited in NMFS 2008a). Spawning takes place from April to June. Reduced numbers of adults are expected from May to December within the action area. The smolt migration past Willamette Falls also begins in early April and extends through early June (Howell et al. 1985 as cited in NMFS 2008a), with migration peaking in early to mid-May.

Steelhead smolts generally migrate away from the shoreline and enter the Columbia via the Multnomah Channel rather than the mouth of the Willamette (NMFS 2008a). Steelhead smolt migration through the Lower Willamette River portion of the action area is expected to peak in May (NMFS 2008a). Reduced smolt presence within the action area is expected in the time period of July to March.

Lower Columbia River Presence: Upper Willamette steelhead spawn in the Willamette River, and thus are only present in the Columbia River below the confluence of the Lower Willamette River. Because there is limited information on the presence and timing of this population within the Lower Columbia River, the presence of adult and juvenile fish in the Lower Columbia River is assumed to be similar to the presence of this DPS in the Lower Willamette River portion of the action area.

3.3.2 Lower Columbia River DPS

The Lower Columbia River DPS includes all naturally spawned steelhead populations below impassable barriers in streams and tributaries to the Columbia River between the Cowlitz and Wind rivers on the Washington side and the Willamette and Hood rivers on the Oregon side as well as 25 hatchery stocks. This DPS does not include steelhead populations in the Upper Willamette River Basin above Willamette Falls or from the Little and Big White Salmon rivers (NMFS 2006b).

Historical estimates of abundance of this specific DPS are unavailable; however, canning records indicate a continual decline in steelhead abundance since the peak in 1892 of 2,231,663 kilograms (kg) (Fulton 1970). Recent records indicate an average adult Lower Columbia River steelhead run of 10,745 fish between 1996 and 2003 (Good et al. 2005).

Factors limiting recovery for Lower Columbia River steelhead are degraded floodplain and stream channel structure and function, reduced access to spawning/rearing habitat, altered streamflow in tributaries, excessive sediment and elevated water temperatures in tributaries, and hatchery impacts (NMFS 2005a, 2006b). NMFS (2007) identified degraded floodplain connectivity and function, channel structure and complexity, riparian areas and large wood recruitment, stream substrate, streamflow, water quality, fish passage, and predation/competition as the major factors limiting recovery of this species.

The Lower Columbia River steelhead DPS was listed as an ESA threatened species on March 19, 1998 (NMFS 1998). This status was reaffirmed on January 5, 2006 (NMFS 2006b).

3.3.2.1 Presence in the Action Area

Lower Columbia River steelhead populations expected to be present within the Columbia River portion of the action area are those that spawn in the Clackamas and tributaries upstream of the Willamette such as the Sandy, Hood, and Wind rivers. Of those populations, only the Clackamas population is expected in the Lower Willamette River portion of the action area. The Lower Columbia River DPS includes both summer- and winter-run populations. Five populations of winter steelhead and one population of summer steelhead exist in Oregon (McElhany et al. 2007). Winter-run fish enter freshwater as mature adults during winter and spring and spawn shortly thereafter. Summer-run fish enter freshwater as immature adults between spring and early fall and spawn after several months of freshwater residence (Myers et al. 2006).

Lower Willamette River Presence: Peak adult abundance within the Lower Willamette River portion of the action area is expected from January to July (PGE 2012). Adults are expected within the action area year-round with reduced numbers present between August and December. Because information related to juvenile migration timing within the Lower Willamette River is limited, juvenile timing is assumed to be similar to Columbia River timing. Juveniles are expected within the action area between April and June, peaking in May (DART 2011). Reduced numbers of juveniles are expected from July to March.

Lower Columbia River Presence: The Lower Columbia River steelhead DPS includes both summer- and winter-run steelhead. As such, adult steelhead are expected to be present in the action area in limited numbers throughout the year. Peak adult migration through the action area is expected to occur between January and July (McElhany et al. 2007; PGE 2012). Reduced numbers of adult steelhead are expected within the action area from August to December. Juveniles rear in freshwater before migrating to sea and display the stream-type life history pattern. Juvenile migration timing is assumed to be similar to general steelhead migration in the Columbia River between April and June, peaking in May (DART 2011). Reduced juvenile presence is expected within the action area from July to March.

3.3.3 Upper Columbia River DPS

The Upper Columbia River steelhead DPS includes all naturally spawned anadromous steelhead populations below natural and constructed impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the United States-Canada border as well as six hatchery stocks (NMFS 2006b). Distribution includes portions of the Wenatchee, Entiat, Methow, and Okanogan drainages (Good et al. 2005). This DPS is only expected to occur within the Lower Columbia River portion of the action area.

Fish ladder counts for this DPS began in 1962 at the Priest Rapids Dam. Only 9,334 fish returned to the Upper Columbia River that year. For all populations, abundance over the most recent 10-year period is below the thresholds that the ICTRT has identified as a minimum for recovery. Abundance for most populations declined to extremely low levels in the mid-1990s, increased to levels above or near the recovery abundance thresholds (all populations except the Okanogan) in a few years in the early 2000s, and more recently is at levels intermediate to those of the mid-1990s and early 2000s. Abundance since 2001 has substantially increased for the DPS as a whole (NMFS 2008a). Recent 2010 dam counts indicate returns to the Upper Columbia River of 26,476 fish, slightly higher than the 10-year average of 18,755 fish (DART 2011, Priest Rapids Dam).

The NMFS identified mortality from the mainstem Columbia River hydropower system, reduced tributary streamflows, tributary riparian degradation and loss of in-river wood, altered tributary floodplain and channel morphology, excessive sediment, and degraded tributary water quality as the major factors limiting recovery of this species (NMFS 2007). Several recent studies suggest reduced productivity of wild steelhead spawning in the wild with hatchery steelhead (Chilcote et al. 2011).

This DPS was originally listed as endangered on August 18, 1997 (NMFS 1997) but was upgraded to threatened on January 5, 2006 (NMFS 2006b).

3.3.3.1 Presence in the Action Area

All fish from this DPS use the Columbia River portion of the action area as a migration and rearing corridor. No fish from this DPS are expected within the Lower Willamette River portion of the action area.

Upper Columbia DPS steelhead are similar to Snake River DPS steelhead although juveniles may outmigrate after an extended freshwater rearing period, which can be up to 7 years (NMFS 1997). Adult steelhead fish return to freshwater June through October and migrate through the Columbia River portion of the action area between June and October, peaking in July, August, and September (FPC 2012). Reduced adult presence within the action area is expected from November to May. Steelhead smolt passage at the Bonneville dam occurs between April and June, peaking in mid-May (DART 2011). Reduced juvenile presence within the action area is expected from July to March.

3.3.4 Middle Columbia River ESU

The Middle Columbia River steelhead DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams from above the Wind River, Washington, and the Hood River, Oregon (exclusive), upstream to, and including, the Yakima River, Washington (NMFS 2006b). This DPS also includes seven hatchery stocks. Major drainages in this DPS include the Deschutes, John Day, Umatilla, Walla Walla, Yakima, and Klickitat drainages as well as smaller tributaries of the Columbia River mainstem (Good et al. 2005). The Snake River is not included in this DPS.

For 3 of the 14 populations with estimates of recent abundance, average abundance over the most recent 10-year period is above the average abundance thresholds that the ICTRT identifies as a minimum for low risk (NMFS 2008a). The remaining 11 populations have lower average abundance than the ICTRT abundance thresholds (NMFS 2008a). In general, abundance for most populations was relatively high during the late 1980s, declined to low levels in the mid-1990s, and increased to levels similar to the late 1980s during the early 2000s (NMFS 2008a).

The NMFS identified mortality in the Columbia River hydropower system, reduced streamflow in tributaries, altered tributary channel morphology, excessive sediment in tributaries, degraded tributary water quality, and harvest and hatchery related adverse effects as the major factors limiting recovery of this species (NMFS 2005c).

This DPS was listed as a threatened species on March 25, 1999 (NMFS 1999b). The status was reaffirmed on January 5, 2006 (NMFS 2006b).

3.3.4.1 Presence in the Action Area

All fish from this DPS use the Columbia River portion of the action area as a migration corridor. No fish from this DPS are expected within the Lower Willamette River portion of the action area. The Middle Columbia River DPS fish are similar in run timing to the Upper Columbia River DPS fish.

Adult steelhead fish return to the Lower Columbia River between June and October. Peak migration through the Columbia River portion of the action area is expected between July and September (FPC 2012). Based on this timing, minimal numbers of the returning adult population are expected within the action area between November and May. Steelhead smolt passage in the Columbia River generally occurs during the months of April, May, and June (DART 2011). Peak migration occurs in May with reduced juvenile abundance from July to March (Figure 3-1; DART 2011).

3.3.5 Snake River Basin DPS

The Snake River steelhead DPS includes all naturally spawned anadromous populations below natural and constructed impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho as well as six hatchery stocks (NMFS

2006b). The life histories of all populations of the Snake River steelhead DPS are consistent with the summer-run ecotype.

Historical estimates of abundance specific to this DPS are unavailable; however, the basin is believed to have supported over half the production of the Columbia River basin (Mallet 1974 as cited in Good et al. 2005). Total returns to the Snake River Basin between 1975 and 1979 dropped to 29,920 fish. Ladder counts at Lower Granite Dam have been increasing since the mid-1970s; however, wild origin steelhead have been declining for the same period. Recent returns to the Snake River Basin in 2010 have increased to over 200,000 fish, with 58,743 naturally spawning fish (DART 2011, Ice Harbor Dam). This DPS was listed as a threatened on August 18, 1997 (NMFS 1997). The status was reaffirmed on January 5, 2006 (NMFS 2006b).

3.3.5.1 Presence in the Action Area

Adult and juvenile fish from this DPS use the Columbia River portion of the action area as a migration corridor as they access upstream spawning reaches and migrate to the ocean. This DPS is not expected to be present in the Lower Willamette River portion of the action area.

Spawning occurs in many of the same drainages as for spring Chinook in this area, including the Tucannon, Grand Ronde, Imnaha, Snake, Salmon, and Clearwater drainages (Good et al. 2005), but steelhead have a greater overall distribution of spawning and rearing areas within these drainages according to StreamNet data (2011). Adult steelhead fish return to freshwater from June through October. Peak migration through the Columbia River portion of the action area is expected between July and September (FPC 2012). Reduced numbers of adult steelhead are expected in the action area from November to May. Steelhead smolt passage at the Bonneville Dam occurs between April and June, peaking in mid-May (DART 2011). Similar to adult presence in the action area, reduced smolt presence in the action area is expected between July and March.

3.4 COLUMBIA RIVER CHUM SALMON ESU

The Columbia River chum ESU includes all naturally spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon as well as three hatchery stocks.

The Oregon portion of the Columbia River chum ESU historically contained eight populations (McElhany et al. 2007), with over a million chum returning in some years to the Columbia River (McElhany 2005). Recently, only a few hundred to a few thousand chum have returned each year to the Columbia, mainly to the Washington side of the Columbia River. All of the historical Oregon populations are considered extirpated or nearly so. The remaining chum populations in Oregon are in the very high risk category, and the ESU is also at very high risk of extinction (McElhany et al. 2007).

The factors limiting recovery for Columbia River chum salmon are altered channel form and stability in tributaries, excessive sediment in tributary spawning gravels, altered streamflow in tributaries and the mainstem Columbia River, loss of some tributary habitat types, and harassment of spawners in the tributaries and mainstem (NMFS 2005a-e, 2006a). NMFS (2007) identified degraded estuarine and nearshore marine areas, floodplain connectivity and function, channel structure and complexity, riparian areas and large wood recruitment, stream substrate, streamflow, and fish passage as the major factors limiting recovery of this species.

Chum salmon from the Columbia River ESU were listed under the ESA as a threatened species on March 24, 1999 (NMFS 1999a), with the listing status reaffirmed in 2005 (NMFS 2005b).

3.4.1 Presence in the Action Area

Native runs of chum are currently extinct in the Willamette watershed (ODFW 2005b). In addition, there are no current hatchery releases of chum into the Willamette or its tributaries. Therefore, no fish from this ESU are expected within the Lower Willamette River portion of the action area. In the Columbia River, chum salmon are limited to areas downstream of Bonneville Dam and are expected to utilize the Columbia River portion of the action area as a rearing and migration corridor.

Specific abundance estimates for the Columbia River portion of the action area are unavailable; however, recent estimates for the Lower Columbia Gorge and Grays River populations indicate a return of 1,300 fish (Good et al. 2005). Adults enter the Columbia River to return to their spawning grounds during the fall months. Chum spawn in the lowermost reaches of rivers and streams, generally in shallower, slower running streams and side channels more frequently than do other salmonid species, and are even known to spawn in the intertidal zones of streams at low tide (Johnson et al. 1997). Chum salmon spawn in shallow water in the main channel of the Columbia River between RMs 113 and 114, near RM 123, and beyond (NMFS 2005e). Adult chum presence in the action area is expected between October and December, peaking in November (Johnson et a. 1997). Reduced presence of adult chum in the action area is expected in the time period of January to September.

In contrast to other salmonids, chum salmon generally migrate to estuarine and ocean waters immediately after hatching. The species has only a single sea-run form. Juvenile chum salmon begin their outmigration immediately upon emergence, and likely move through the Columbia River portion of the action area between January and early May (Johnson et al. 1997). Freshwater feeding may be limited during downstream migration, with aquatic insect larvae making up the bulk of juvenile chum diets during this time (Salo 1991). Reduced presence of juvenile chum is expected within the action area during the time period of June to December.

The Lower Columbia River portion of the action area is considered a migration corridor for both juvenile and adult fish, although some foraging may occur by juveniles while passing through the area. These smaller ocean-type fish are more likely to be dependent on the shallower waters near the riverbank. Chum may reside in the estuary for a period of a few hours to a few weeks, depending primarily on foraging success and age (Johnson et al. 1997).

3.5 SNAKE RIVER SOCKEYE SALMON ESU

The Snake River sockeye ESU includes all populations of sockeye salmon from the Snake River Basin, Idaho, as well as hatchery stocks from the Redfish Lake captive propagation program.

Five lakes in Idaho's Stanley Basin historically contained sockeye salmon: Alturas, Pettit, Redfish, Stanley, and Yellowbelly (Bjornn et al. 1968). Today, they only occur in Redfish Lake. Sockeye counts at the Redfish Lake weir in 1985, 1986, and 1987 were 11, 29, and 16, respectively (Good et al. 2005). The first adult returns from the captive broodstock program returned to the Stanley Basin in 1999. From 1999 through 2007, a total of 355 captive brood program adults that had migrated to the ocean returned to the Stanley Basin.

By 2010, returns from the captive broodstock program had increased to 1,302 fish. However, numbers of natural-origin sockeye salmon to the Stanley Basin have remained extremely low; no natural-origin, anadromous adults have returned since 1998. At this time, the species is entirely supported by adults produced in the captive propagation program. Recent smolt-to-adult survival of sockeye smolts released in the Stanley Basin has rarely been greater than 0.3 percent (Hebdon et al. 2004). The current average productivity likely is substantially less than the productivity required for any population to be at low (1 to 5 percent) extinction risk at the minimum abundance threshold. The Biological Review Team (BRT) determined that the Snake River sockeye salmon remains in danger of extinction (Good et al. 2005).

The NMFS identified reduced tributary streamflow, impaired tributary passage and blockages to migration, and mortality from the Columbia River hydropower system as the major factors limiting recovery of this species (NMFS 2005b).

Sockeye salmon from the Snake River ESU were listed as threatened on November 20, 1991 (NMFS 1991), with their status elevated to endangered in 2005 (NMFS 2005b).

3.5.1 Presence in the Action Area

Sockeye life histories were reviewed extensively by Burgner (1991). Snake River sockeye spend 2 to 3 years in the ocean before returning to their natal lake to spawn. Adult Snake River sockeye are expected to migrate through the Columbia River portion of the action area between June and July (FPC 2012). Spawning typically peaks in mid-October. The majority of sockeye salmon spawn either in inlet or outlet streams of lakes or in lakes themselves. Reduced numbers of sockeye are expected within the action area from August to April.

Fry emerge in late April and May and move immediately to the open waters of the lake where they feed on plankton for 1 to 3 years before migrating to the ocean. Juvenile sockeye generally leave the Stanley Basin Lakes from late April through May. While pre-dam reports indicate that sockeye salmon smolts migrated through the lower Snake River in May and June, passive integrated transponder (PIT)-tagged smolts from the Redfish Lake captive broodstock program pass Lower Granite Dam during mid-May to mid-July. Smolt data from the Bonneville dam indicate that juvenile sockeye are expected within the action area between April and June, peaking in May (DART 2011). Reduced juvenile presence is expected within the action area from July to March.

Recent fish counts indicate a returning population of 1,302 fish in 2010, and a 10-year average of only 197 fish (DART 2011, Ice Harbor Dam). The Columbia River portion of the action area serves as a migration corridor for these fish, but not as spawning or rearing habitat. No fish from this ESU are expected within the Lower Willamette River portion of the action area. Both adult and outmigrating juvenile sockeye are expected to migrate quickly through the Columbia River portion of the action area. Migrating adults do not forage in freshwater, whereas juveniles may exhibit limited foraging on primarily planktonic organisms. Outmigrating sockeye juveniles are not shoreline-dependent.

3.6 SOUTHERN POPULATION OF GREEN STURGEON

There are two DPSs defined for green sturgeon: a northern DPS (NDPS) with spawning populations in the Klamath and Rogue rivers and a southern DPS (SDPS) that spawns in the Sacramento River (NMFS 2007). The SDPS includes all spawning populations of green sturgeon south of the Eel River in California, and was listed as threatened in 2006 (NMFS 2006c). The NDPS remains a species of concern. SDPS green sturgeon were first determined to occur in Oregon and Washington waters in the late 1950s when tagged San Pablo Bay green sturgeon were recovered in the Columbia River estuary (California Department of Fish and Game [CDFG] 2002). Preliminary work by Israel and May (2006) has determined that 80 percent or greater of green sturgeon in the Columbia River estuary during late summer and early fall months were SDPS origin.

3.6.1 Presence in the Action Area

Green sturgeon is a widely distributed, marine-oriented species found in nearshore waters from Baja California to Canada (NMFS 2007 as cited in NMFS 2008b). Their estuarine/marine distribution and the seasonality of estuarine use range-wide are largely unknown. Green sturgeon are anadromous, spawning in the Sacramento, Klamath, and Rogue rivers in the spring (NMFS 2007 as cited in NMFS 2008b). Spawning occurs in deep pools or holes in large, turbulent river mainstreams. Specific characteristics of spawning habitat are unknown but likely include large cobbles but can range from clean sand to bedrock (NMFS 2007 as cited in NMFS 2008b).

Green sturgeon congregate in coastal waters and estuaries, including non-natal estuaries, where they are vulnerable to capture in salmon gillnet and white sturgeon (*Acipenser transmontanus*) sport fisheries. Sturgeon migrations are probably related to feeding and spawning (Beamis and Kynard 1997 as cited in NMFS 2008b). Green sturgeon captured during the sport season for white sturgeon could suggest they are feeding in the estuary. However, contradictory evidence in the form of empty stomach contents of green sturgeon captured in the Columbia River gillnet fishery suggests that these green sturgeon were not actively foraging in the estuary (USACE 2007 as cited in NMFS 2008b).

Information from fisheries-dependent sampling suggests that green sturgeon only occupy large estuaries during the summer and early fall in the northwestern United States. Commercial catches of green sturgeon peak in October in the Columbia River estuary, and records from other estuarine fisheries (i.e., Willapa Bay and Grays Harbor, Washington) support the idea that sturgeon are only present in these estuaries from June until October (Moser and Lindley 2007 as cited in NMFS 2008b).

However, most green sturgeon taken are by-catch in fisheries for salmonids, *Oncorhynchus* spp., and white sturgeon (Moyle 2002; Adams et al., 2002 as cited in NMFS 2008b). Consequently, data from fisheries dependent sampling may be a poor indicator of green sturgeon distribution in estuaries. Green sturgeon enter the Columbia River at the end of spring with their numbers increasing through June. The greatest numbers are caught in the estuary in July through September. The majority of green sturgeon are caught in the lower reaches of the Columbia (29,132 from RM 1 to 20 and 8,086 from RM 20 to 52) based upon harvest information from 1981 through 2004. A few green sturgeon may be found as far upriver as Bonneville Dam, but there are no known spawning populations in the Columbia River and its tributaries (USACE 2007 as cited in NMFS 2008b).

Individuals from the SDPS of North American green sturgeon could migrate through and hold in deeper areas of the action area as subadults or adults mainly between July through September or October; however, it is unlikely that green sturgeon would be found in large numbers within the action area at any time of year.

3.7 SOUTHERN POPULATION OF PACIFIC EULACHON

Eulachon are small, ocean-going members of the smelt family Osmeridae that occur in offshore marine waters and return to rivers to spawn in late winter and early spring in tidal portions of the rivers. They are present in the mainstem Columba River up to approximately the Bonneville Dam. Major eulachon spawning regularly occurs in some tributaries of the Columbia River, including the Cowlitz River, although specific spawning distribution is not well understood (WDFW and ODFW 2001; NMFS 2010a). Eulachon were listed as threatened effective May 17, 2010.

3.7.1 Presence in the Action Area

Eulachon returning to spawn in the mainstem Columbia River and its tributaries downstream of Bonneville Dam typically enter the Columbia River from early January through as late as May, although a small ‘pilot’ run has been observed to enter as early as December. Eulachon typically spawn every year in the Cowlitz River, with inconsistent runs and spawning events occurring in the Grays, Elochoman, Lewis, Kalama, and Sandy rivers. Peak tributary abundance is usually observed in February, with variable abundance through March, and an occasional showing in April (ODFW and WDFW 2009). Peak spawning typically occurs in February and March (Washington Department of Fish and Wildlife [WDFW] and ODFW 2001). Based on harvest data from 1949 through 2008, the earliest recorded initial arrival of eulachon in the Columbia River mouth is December 13, the latest recorded initial arrival is February 21; the average arrival date is January 8 (WDFW and ODFW 2001).

Spawning occurs as far upstream as RM 122 in the Washougal River on the Washington side of the Columbia River (above the northeastern corner of Lady Island) (WDFW 2008) and in the Sandy River on the Oregon side (USACE 2003). The Sandy River is the only tributary in Oregon that is known to support a run of eulachon (Williams 2009, as cited in Drake et al. 2010). Eulachon arrival in the Sandy River, just upstream of the Willamette, typically occurs a few weeks after arrival in the Columbia River, with the earliest recorded arrival date of February 28, the latest recorded arrival date of April 21, and an average arrival date of March 21 (Drake et al. 2010). All eulachon spawning in the Sandy River and other Columbia River tributaries upstream of the action area migrate through the Columbia River portion of the action area. However, no eulachon are expected to migrate through or spawn in the Lower Willamette River portion of the action area.

Eulachon spawn-timing and egg incubation are temperature-dependent. Eulachon spawn on a variety of substrates, but pea gravel and coarse sand is the most common medium where incubating eggs are observed (WDFW and ODFW 2001). Eggs have a sticky outer membrane and adhere to the gravel/sand substrates. Larvae typically hatch and emerge within 30 to 40 days of spawning and immediately begin transiting toward the estuary (Smith and Saalfield 1955 in Drake et al. 2010). Larvae, which are planktivorous, drift rapidly downstream through the estuary and into saltwater where they rear in nearshore marine areas for up to several weeks before moving to offshore marine areas and eventually deeper marine waters. Adults and juveniles commonly forage at moderate depths (20 to 150 meters [66 to 292 feet]) in nearshore marine waters (Hay and McCarter 2000). Eulachon adults cease feeding during the freshwater spawning migration (NMFS 2010a).

Eulachon are an important prey species for a variety of other fishes, mammals, and birds. Historically, their distribution ranged from northern California to the Bering Sea, Alaska. Currently, their range extends from the Mad River in Northern California north into British Columbia; those eulachon that spawn south of the Canadian border are included in the SDPS.

The recent dramatic decline in the abundance of the SDPS of eulachon is likely due to a number of different factors. Often cited are changes in the timing of California, Oregon, and Washington spring river flows (NMFS 2010a), which are critical to spawning success. Other threats include vulnerability to capture in shrimp fisheries in the United States and Canada, reduced flows in the Columbia River and Klamath River basins, and seal and sea lion predation (NMFS 2010a).

Based on the information provided above, adult and larval eulachon may be present in the Lower Columbia River portion of the action area from December through May each year, with peak spawning expected to occur in February or March.

3.8 CRITICAL HABITAT STATUS AND DESCRIPTION

Critical habitat is defined under Section 3(5)(A) of the ESA as: "the specific areas within the geographical area occupied by the species, at the time it is listed on which are found those physical or biological features that are essential to the conservation of the species and which require special management consideration or protection; and specific areas outside the geographical area occupied by the species at the time it is listed…upon determination by the Secretary that such areas are essential for the conservation of the species." Once critical habitat is designated, Section 7 of the ESA requires federal agencies to ensure they do not fund, authorize, or carry out any action that will destroy or adversely modify that habitat. This requirement is in addition to the Section 7 requirement that federal agencies ensure their actions do not jeopardize the continued existence of listed species.

The area of designated critical habitat for the salmonid ESUs and DPSs within freshwaters extends laterally to the upper elevation boundary defined by the ordinary high water (OHW) line as defined by USACE in 33 CFR 329.11. USACE in 33 CFR 329.11 defines OHW on non-tidal rivers as "the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas."

3.8.1 Critical Habitat for Salmon and Steelhead

The action area is within designated critical habitat for each of the salmon and steelhead ESUs and DPSs discussed in this BA. Critical habitat was established for these ESUs and DPSs in 1993 and in 2005. Critical habitat was proposed for Lower Columbia River coho in 2013.

On December 28, 1993, critical habitat was designated for:

- Snake River spring/summer-run Chinook
- Snake River fall-run Chinook
- Snake River sockeye salmon

On September 2, 2005, critical habitat was designated for:

- Upper Columbia River Chinook salmon
- Lower Columbia River Chinook salmon

- Upper Willamette River Chinook salmon
- Columbia River chum
- Snake River Basin steelhead
- Upper Columbia River steelhead
- Middle Columbia River steelhead
- Lower Columbia River steelhead
- Upper Willamette River steelhead

On January 14, 2013 critical habitat was proposed for:

- Lower Columbia River Coho salmon

In reaches designated or proposed as critical habitat, NMFS considers physical and biological habitat features needed for life and successful reproduction of the species. These necessary habitat features are referred to as Primary Constituent Elements (PCEs). On December 28, 1993, NMFS identified the following four PCEs for salmon ESUs listed above (NMFS 1993):

- Spawning and juvenile rearing sites
- Juvenile migration corridors
- Areas for growth and development to adulthood
- Adult migration corridors

On September 2, 2005, NMFS identified the following six PCEs for the salmon and steelhead ESUs and DPSs listed above (NMFS 2005d):

- Freshwater spawning sites
- Freshwater rearing sites
- Freshwater migration corridors
- Estuarine areas
- Nearshore marine areas
- Offshore marine areas

On January 14, 2013, NMFS proposed the following PCEs for the Lower Columbia River Coho (NMFS 2013):

- Freshwater spawning sites
- Freshwater rearing sites
- Freshwater migration corridors

Regarding the species present in the action area, NMFS reviews the status of critical habitat affected by the action by examining the condition and trends of PCEs throughout the designated area. Designated critical habitat reaches identify areas occupied by a listed species at the time of the designation within which PCEs may exist. However, the existence and condition of PCEs varies from site to site within a designated reach, such that not every site within the reach contains designated critical habitat.

3.8.1.1 Lower Willamette River PCEs

According to the definitions provided for PCEs in designating critical habitat, the Lower Willamette River portion of the action area provides the following two PCEs for Lower Columbia River Chinook, Upper Willamette River Chinook, Lower Columbia River steelhead, and Upper Willamette River steelhead:

- Freshwater migration corridors
- Freshwater rearing sites

The physical and biological features important for freshwater migration include corridors free of obstructions with high water quality and quantity and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features support juvenile and adult mobility and survival. These features allow juveniles to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner. Similarly, these features are essential for adults because they allow fish in a non-feeding condition to successfully swim upstream, avoid predators, and reach spawning areas on limited energy stores (Federal Register Vol. 70 No.170).

The important physical and biological freshwater rearing features include sufficient water quantity and floodplain connectivity to form and maintain the physical habitat conditions that support juvenile growth and mobility; water quality and forage to support juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because, without them, juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure survival (NMFS 2005d).

The critical habitat PCEs in the Lower Willamette River portion of the action area for salmon and steelhead are limited by several factors: high summer temperatures in the Lower Willamette River, the lack of floodplain connectivity, lack of shallow water habitat, altered hydrology, lack of complex habitat to provide forage and cover, and the presence of hardened shorelines. Additional information on the existing condition of salmonid critical habitat PCEs is provided in Section 4.2.

3.8.1.2 Lower Columbia River PCEs

The Columbia River portion of the action area is designated as critical habitat for all ESUs and DPSs present in the action area. Specifically, the Columbia River is utilized as a migration and rearing corridor for ESUs and DPSs accessing upstream spawning reaches. As such, the PCEs discussed in the previous section for listed salmonid species also apply in the Lower Columbia River portion of the action area along with the following PCEs that apply to the Snake River Chinook and Sockeye Salmon ESUs:

- Juvenile migration corridors: cover/shelter, food, riparian vegetation, safe passage space, substrate, water quality, water quantity, water temperature, and water velocity

- Adult migration corridors: cover/shelter, riparian vegetation, safe passage, space substrate, water quality, water quantity, water temperature, and water velocity

3.8.2 Critical Habitat for Green Sturgeon

Critical habitat was designated for the SDPS of North American green sturgeon in October 2009 (NMFS 2009a). Designated critical habitat is divided into two sections: one representing the lower estuary from the river mouth to the maximum extent of saltwater intrusion at approximately river kilometer (RKM) 74 (approximately RM 46) and one representing the lower river consisting of tidal freshwater from RKM 74 to Bonneville Dam at RKM 146. The Willamette River is excluded from designated critical habitat (NMFS 2009b).

PCEs present in both the lower estuary and the lower Columbia River include food resources, water flow, water quality, depth, and migratory corridors to support migration, aggregation and holding, and feeding by subadult and adult green sturgeon (NMFS 2009b).

3.8.3 Critical Habitat for Eulachon

Critical habitat for eulachon was designated on October 20, 2011 (NMFS 2011a) for the Lower Columbia River, its estuary, and tributaries in Oregon and Washington up to the Bonneville Dam at RM 146 and laterally to the extent of OHW. In Oregon and Washington, the Lower Columbia River and its tributaries support the largest known spawning run of eulachon. The mainstem of the lower Columbia River provides spawning and incubation sites and a large migratory corridor to spawning areas in the tributaries. Major tributaries of the Columbia River that have supported eulachon runs in the past include the Grays, Elochoman, Cowlitz, Kalama, and Lewis rivers in Washington and the Sandy River in Oregon. No critical habitat has been designated in the Willamette River.

Three physical or biological features essential for conservation have been designated for eulachon critical habitat as follows (NMFS 2011a); however, only two are relevant for the action:

- Freshwater spawning and incubation sites with water flow, quality, and temperature conditions and substrate supporting spawning and incubation.
- Freshwater and estuarine migration corridors free of obstructions and with water flow, quality, and temperature conditions that support larval and adult mobility and abundant prey items supporting larval feeding after the yolk sac is depleted.

3.9 COLUMBIA RIVER BULL TROUT ESU

USFWS listed bull trout as a threatened species within the contiguous United States in 1998 (USFWS 1998). The species has both resident and migratory types and is iteroparous. There are three types of migratory fish: river migrants, migrants to lakes or reservoirs, and migrants to saltwater. Spawning typically occurs August through November, although migratory fish may begin spawning migrations earlier depending upon migration distance. Spawning in the Lewis River population occurs late August through mid-September. Bull trout typically emerge from the spawning gravel in April or May. Juveniles and adults are opportunistic feeders. Juveniles may feed on terrestrial and aquatic insects, large zooplankton, and small fish; adults are primarily piscivorous. Small bull trout eat terrestrial and aquatic insects but shift to preying on other fish as they grow larger. Adult bull trout prey on whitefish, sculpins, and other trout as they grow larger.

The Lower Columbia River bull trout DPS occurs throughout the entire Columbia River Basin within the United States and its tributaries, excepting those fish found in the Jarbidge River, Nevada, which are considered a separate DPS. The historical range of bull trout includes about 60 percent of the Columbia River Basin. Today, bull trout are limited to approximately half of their historical range. Only two drainages below the Bonneville Dam currently support bull trout: the Lewis River and the Upper Willamette River (USFWS 1998). The decline of bull trout can be attributed to development, logging, and agriculture-related habitat degradation.

There is an ongoing effort to restore a “non-essential experimental” population of bull trout in the Clackamas River (USFWS 2011). As of 2013, 118 adult and subadult and 570 juvenile bull trout have been translocated to the Clackamas River (Allen and Koski 2013). It is not expected that these fish would be present in any portion of the action area.

3.9.1 Presence in the Action Area

Bull trout prefer the upper reaches of cold, clear running streams with clean gravel and cobble substrate for spawning. Bull trout are not known to spawn within the action area. Juvenile and adult bull trout could be present in the action area at any time, but in very small numbers. Juveniles are more likely to be larger in size in the action area than juvenile salmon because few bull trout spawning areas occur near the action area. Although individual bull trout could be present at any time in the mainstem Columbia River, extensive use has not been documented (USACE 2004). Bull trout in the area would have to have migrated over long distances before reaching the action area. Adult bull trout, similar to adult salmon, are expected to pass through the action area quickly during upstream migration without feeding.

3.9.2 Critical Habitat for Bull Trout

The Lower Columbia River was included in the revised bull trout critical habitat listing effective November 17, 2010 (USFWS 2010b) based on its importance as forage, migration, and overwintering (FMO) habitat (USFWS 2009). FMO is defined by USFWS as "relatively large streams and mainstem rivers, including lakes or reservoirs, estuaries, and nearshore environments, where subadult and adult migratory bull trout forage, migrate, mature, or overwinter. This habitat is typically downstream from spawning and rearing habitat and contains all the physical elements to meet critical overwintering, spawning migration, and subadult and adult rearing needs. Although use of foraging, migrating, and overwintering habitat by bull trout may be seasonal or very brief (as in some migratory corridors), it is a critical habitat component" (USFWS 2010b).

USFWS determined that the Lower Columbia River is essential for maintaining bull trout distribution and provides essential FMO habitat for populations of bull trout in the Lewis, Hood, Klickitat, and Deschutes rivers and connectivity between these core areas; it has not been identified as spawning or breeding habitat (USFWS 2010b). For bull trout, nine PCEs were identified as components of critical habitat (USFWS 2010b), and of these, several apply to the habitat within the action area:

- Springs, seeps, groundwater sources, and subsurface water connectivity (hyporeheic flows) to contribute to water quality and quantity and provide thermal refugia

- Migratory corridors with minimal physical, biological, or chemical barriers between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows

- An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish

- Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structure

- A natural hydrograph, including peak, high, low, and base flows within historical ranges or, if regulated, a hydrograph that demonstrates the ability to support bull trout populations

- Sufficient water quality and quantity such that normal reproduction, growth, and survival are not limited
- Few or no non-native predatory (e.g., lake trout, walleye, northern pike, and smallmouth bass), inbreeding (e.g., brook trout), or competitive (e.g., brown trout) species present

For bull trout, the Columbia River portion of the action area waterward of 10.75 feet mean lower low water (MLLW) (approximately +18 feet Columbia River Datum [CRD]) is critical habitat and includes PCEs important for support of the FMO habitat identified for the Lower Columbia River.

3.10 SOUTHERN RESIDENT KILLER WHALE DPS

The Southern Resident killer whale was listed as an endangered species on November 18, 2005 (NMFS 2005f), and this status was reaffirmed in 2011 (NMFS 2011c). NMFS designated critical habitat for Southern Resident killer whales in 2006 (NMFS 2006d). Critical habitat does not occur in the action area.

Resident killer whales in the U.S. are distributed from California to Alaska, with four distinct communities recognized: Southern, Northern, Southern Alaska, and Western Alaska. The Southern Resident DPS consists of three pods, identified as J, K, and L pods. These pods reside for part of the year in the inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), principally during the late spring, summer, and fall (NMFS 2006e).

Killer whales feed on a variety of marine organisms, including fish, squid, and marine mammals. Southern Resident killer whales show a strong preference for Chinook salmon (78 percent of identified prey) during late spring to fall (Ford and Ellis 2006; NMFS 2008c). Chum salmon (11 percent) are also taken in significant amounts, especially in autumn. Other fish species eaten include coho, steelhead, sockeye, and non-salmonid fish species.

3.11 PACIFIC LAMPREY

The Pacific lamprey (*Entosphenus tridentatus* formerly *Lampetra tridentata*) is an anadromous and parasitic fish widely distributed along the Pacific coast of North America and Asia. Although Pacific lamprey are not an ESA-listed species and therefore not covered in this BA, they are designated as a species of concern by the USFWS due to their cultural significance and declining populations. Lamprey populations in the Upper, Middle, and Lower Columbia and Snake rivers have declined significantly, due primarily to artificial barriers to migration, poor water quality, predation, decline in prey, dredging, and dewatering (Luzier et al. 2011).

After spending between 6 months to 3.5 years in the marine environment, Pacific lamprey return to fresh water primarily during spring and summer months. They often spend about 1 year in freshwater habitat before spawning, usually holding under large boulders, bedrock crevices, and other large substrate associated with low water velocities until the following spring when they move to spawning areas. Adult lampreys spawn generally between March and July in gravel bottom streams, usually at the upstream end of riffle habitat near suitable habitat for larvae (ammocoetes), and die after spawning. Dependent on location within their distribution range, adult lampreys can be present at spawning areas and preparing to spawn from February to September. The peak period within the Columbia River basin is primarily from March 1 through July 1 in lower and mid elevation reaches. Nests are present from March 1 through August 1. Following an incubation period of between 18 and 49 days, ammocoetes emerge and drift downstream to areas of low stream velocity and burrow into sand or silt substrate. Emergence and settling into suitable habitat generally occurs from April to August (USFWS 2010a).

Suitable habitat for ammocoetes includes low velocity pools and stream margins with a dominant substrate of fine silt, sand, or small gravels. Low to moderate gradient stream reaches with a mix of silt and cobble substrate may offer optimal spawning and rearing habitat. Streams and rivers where natural flows are low velocity, such as those in low gradient reaches, are important characteristics associated with lamprey presence (USFWS 2010a).

Lamprey ammocoetes spend 3 to 7 years in the sediment filter-feeding on detritus, diatoms, and algae. Ammocoetes move downstream during high flow events or if disturbed. Metamorphosis of ammocoetes into the sub-adult form or “macropthalmia” occurs generally from July through November but is variable depending on distance from salt water. Outmigration to the ocean occurs during or shortly after transformation, generally peaking with rising stream and river flows in late winter or early spring (USFWS 2010a).

In 2012, a Conservation Agreement was developed and signed by local tribes, states, federal agencies, non-governmental organizations, and other stakeholders (USFWS 2012). The purpose of the Conservation Agreement is to reduce threats to Pacific Lamprey and improve their habitats and population status. Through this Conservation Agreement, several parties have agreed to evaluate lamprey prior to implementation of projects in the vicinity of the proposed action, including surveys for lamprey prior to construction or restoration efforts.

3.12 SPECIES NOT COVERED IN THIS BA

Current species lists were obtained from NMFS for marine/anadromous species at http://www.nmfs.noaa.gov/pr/species/esa/ and from USFWS for freshwater and terrestrial species at http://www.fws.gov/endangered/. Species identified on these lists but not covered in this BA are those that 1) have no potential to occur in the vicinity of the proposed action due to lack of suitable habitat and/or 2) may occur but are not expected to be impacted by the proposed action. However, if during remedial design it is determined that additional species potentially would be impacted, they would be evaluated and assessed through the SMA-specific ESA consultation process.

The following species are not evaluated in this BA:

- Oregon spotted frog (*Rana pretiosa*)
- Yellow-billed cuckoo (*Coccyzus americanus*)
- Northern spotted owl (*Strix occidentalis caurina*)
- Marbled murrelet (*Brachyramphus marmoratus*)
- Streaked horned lark (*Eremophila alpestris strigata*)
- Bradshaw's desert-parsley (*Lomatium bradshawii*)
- Golden paintbrush (*Castilleja levisecta*)
- Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*)
- Nelson's checker-mallow (*Sidalcea nelsoniana*)
- Water howellia (*Howellia aquatilis*)
- Willamette daisy (*Erigeron decumbens*)
- Fender's blue butterfly (*Icaricia icarioides fender*)
- Canada lynx (*Lynx canadensis*)
- Columbian white-tailed deer (*Odocoileus virginianus leucurus*)
- Fisher (*Martes pennant*)
- Gray wolf (*Canis lupus*)
- Red tree vole (*Arborimus longicaudus*)

4.0 ENVIRONMENTAL BASELINE

The environmental baseline is defined as the existing condition of the habitat for each listed species. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the proposed action area, the anticipated impacts of all proposed federal projects in the proposed action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation of this proposed action (50 CFR§402.02).

Any proposed action must be evaluated in the context of the existing environmental baseline in order to determine whether the proposed action, when added to the "present and future human and natural contexts," will jeopardize listed species (National Wildlife Federation [NWF] v. NMFS) 524 F.3d 917 at 930 (9th Circuit 2007). Where baseline conditions imperil a species, a new action can be taken as long as it does not "cause some new jeopardy" or "deepen the jeopardy by causing additional harm," or cause "some deterioration in the species' pre-action condition" NWF v NMFS, 524 F.3 at 930.

As described in the proposed action area section of this document (Section 2.7), the proposed action area includes portions of both the Lower Willamette River and the Lower Columbia River.

Most of the significant negative effects of the proposed action are generally expected to occur within the contaminated portions of the Site where active remediation would occur. As such, the remainder of this section provides detailed environmental baseline information for the Lower Willamette River and more generalized information for the Lower Columbia River portions of the proposed action area.

4.1 LOWER WILLAMETTE RIVER REGIONAL SETTING

The Willamette River flows nearly 200 miles from the Cascade Mountains to the Lower Columbia River and drains the approximate 11,500 square mile basin between the Cascade and the Coast ranges (EPA 2006b). The Willamette River basin encompasses approximately 12 percent of the state of Oregon and supports approximately 70 percent of the state's population as it flows through Oregon's three largest cities and most fertile agricultural land (EPA 2003b; Payne and Baker 2002). The river is the tenth largest river in the continental United States in total discharge and accounts for approximately 15 percent of the total flow in the Columbia River (EPA 2003b; Payne and Baker 2002). The Willamette River basin's climate is characterized by cool, wet winters and warm, dry summers with approximately only 5 percent of total annual precipitation occurring in July, August and September (Payne and Baker 2002). Willamette River basin streamflow strongly correlates with precipitation as, on average, 60 to 85 percent of the runoff occurs between October and March (Uhrich and Wentz 1999).

Historically, the north reach of the river, flowing from Willamette Falls in Oregon City through Portland and to the Willamette River's mouth on the Columbia, was one of the most unconstrained of the river reaches below Willamette Falls. Today, this reach contains the most heavily industrialized area of Oregon. Portland Harbor is the most heavily industrialized reach of the Lower Willamette River and is located immediately downstream of downtown Portland, extending almost to the river's confluence with the Columbia River. The harbor has been the site of manufacturing, shipbuilding, petroleum storage and distribution, metals salvaging, and electrical power generation activities for over a century. A municipal stormwater and sewage overflow system was also designed to discharge into the Lower Willamette River. Since the late 1800s, the harbor has been extensively modified by wetland draining, channelization, and dredging for creation and maintenance of the navigation channel and ship berthing areas (LWG, as modified by EPA 2016). The Lower Willamette River has been deepened and narrowed through channelization, diking, and filling, and approximately 79 percent of the shallow water habitat has been converted to deep water habitat (Northwest Power and Conservation Council 2004). A large portion of the upland area adjacent to the Site on both sides of the river is zoned industrial within the River Industrial Greenway overlay (City of Portland 2010). Little, if any, original shoreline or river bottom exists that has not been modified by the above actions or as a result of them.

4.2 CRITICAL HABITAT PRIMARY CONSTITUENT ELEMENTS FOR PACIFIC SALMONIDS

On September 2, 2005, NMFS designated critical habitat within the Site for the Upper Willamette River and Lower Columbia River Chinook and steelhead populations (NMFS 2005b). At the time NMFS designated this critical habitat, the conditions within the Study Area were highly degraded because the Study Area includes the Portland Harbor Superfund Site, which was designated under CERCLA on December 1, 2000 (EPA 2000).

The ESA limits designation of critical habitat to those areas where PCEs are "found." 16 USC § 1532(5)(A) defines critical habitat as the "specific areas within the geographic area occupied by the species…on which are found those physical or biological features…essential to the conservation of the species."

Critical habitat conditions in the Lower Willamette River were highly degraded at the time NMFS designated critical habitat in 2005. Critical habitat baseline conditions have not changed on a Site-wide basis to date.

The two PCEs that are found in the proposed action area include:

- Freshwater rearing- sites with water quality and floodplain connectivity that support juvenile growth and mobility, as well as sites with water quality and forage that support juvenile development, among other characteristics (NMFS 2005d)

- Freshwater migration- sites that, among other things, are free of obstructions with water quantity and quality conditions that support juvenile and adult mobility and survival (NMFS 2005d)

Baseline conditions for these two PCEs are described in the sections below based on the essential physical and biological features for the freshwater rearing sites and freshwater migration corridors, which include water quality, water quantity, floodplain connectivity, natural cover, forage (and prey species availability), and absence of artificial obstructions.

4.2.1 Water Quality

The entire Site is water quality limited as the 2010 DEQ's CWA section 303(d) list identified the stretch of the Willamette River from Willamette Falls to its mouth on the Columbia as water quality limited for temperature, fecal coliform, biological criteria (fish skeletal deformities), and toxics (mercury in fish tissue, dieldrin, aldrin, PCBs, DDT/DDE, dioxin [2,3,7,8-TCDD], PAHs, manganese, iron, and pentachlorophenol) (DEQ 2012).

4.2.1.1 General Water Quality Parameters

DEQ maintains water quality monitoring sites throughout Oregon. The most recent trends in water quality were measured by the Oregon Water Quality Index for 1997 to 2006 (DEQ 2007b). Two monitoring sites are located in the Lower Willamette River channel (DEQ 2007b) at RM 7.0 (Southern Pacific Railroad Bridge) and upstream of the Site at RM 13.2 (Hawthorne Bridge). The index analyzes a defined set of water quality variables and produces a score describing general water quality. The water quality variables used include temperature, dissolved oxygen (DO), biochemical oxygen demand, pH, total solids, ammonia and nitrate nitrogen, total phosphorous, and bacteria. The score produced to describe general water quality ranges from 10 (worst case) to 100 (ideal water quality). Water quality at RM 7.0 was classified as "fair" (minimum seasonal average index score of 82), while the water quality at RM 13.2 was classified as "good" (minimum seasonal average index score of 85). Overall, there were no significant trends noted from 1997 to 2006 at RM 7.0, while at RM 13.2, a decreasing score was noted (DEQ 2007b).

Factors leading to a decreasing trend may include increased levels of point or non-point source activity and/or decreased flows (DEQ 2007b). In addition, results from the temperature monitoring data indicate that 68 percent of the values at RM 7.0 and 61 percent of the values at RM 13.2 collected during the summer exceed the temperature water quality standard of 68°F.

4.2.1.2 Toxics

The LWG conducted surface water investigations between November 2004 and March 2007 (LWG, as modified by EPA 2016). The LWG BERA (Windward 2011) provides a comprehensive evaluation of potentially unacceptable risk to ecological receptors under conservative baseline exposure scenarios. For fish, including salmonids, effects from Lower Willamette River media were evaluated using tissue-residue, dietary, and surface water screening approaches. For juvenile salmonids, no whole body tissue sample concentrations were measured above toxicity reference values (TRVs). For a specific contaminant, the TRV provides a conservative chemical concentration estimate in a given exposure medium (or tissue) below which potentially unacceptable risks are not expected to occur. For other insectivorous fish (e.g., peamouth and sculpin), whole body sample concentrations were measured above TRVs for copper, lead, total PCBs, and total DDx, but hazard quotients (HQs) were low, which is an indication that the likelihood of potentially unacceptable risk is low.

Dietary evaluations indicated potentially unacceptable risk to juvenile Chinook salmon and other insectivores from cadmium, copper, mercury, and TBT. Individual surface water samples exceeded chronic aquatic life water quality criteria/standards or benchmarks for zinc (in 1 of 167 samples, maximum HQ = 1.1), monobutyltin (in 1 of 167 samples, based on the TBT TRV, maximum HQ = 1.2), benzo(a)anthracene (in 2 of 245 samples, maximum HQ = 10), benzo(a)pyrene (BaP) (in 3 of 245 samples, maximum HQ = 14), naphthalene (in 10 of 268 samples, maximum HQ = 50), bis-2(ethylhexyl) phthalate (BEHP) (in 2 of 190 samples, maximum HQ = 2.3), total DDx (in 1 of 170 samples, maximum HQ = 1.8), ethylbenzene (in 1 of 23 samples, maximum HQ = 1.6), and trichloroethene (in 1 of 23 samples, maximum HQ = 4.1). All exceedance frequencies were less than 5 percent. Except for the PAHs, which had HQs ranging from 10 to 50, the magnitude of HQs was low, with the maximum only slightly exceeding 1.0, and the exceedances were not temporally or spatially consistent. No chemicals exceeded aquatic life criteria based on an SMA-wide average water concentration.

In addition, public and private outfalls are located on both shores of the river within the Site. These outfalls have historically discharged stormwater, municipal waste (both historically through direct sewage discharges and more recently through combined sewer overflows, most of which have now been eliminated), and industrial wastewater to the Site from numerous drainage basins that have a variety of land uses and facilities (LWG, as modified by EPA 2016). Stormwater inputs, along with other known external source loads, including watershed/upstream, groundwater, and process water discharges (i.e., National Pollutant Discharge Elimination System [NPDES] permitted discharges), represent a significant source of contaminants (particularly for total PCBs) within the Site.

In addition to areas adjacent to the Site, land uses in the Willamette Basin upstream of the Site, such as agriculture, industry, transportation, and residential areas historically and currently discharge municipal, agricultural, and industrial wastewater and stormwater directly to the Willamette River and indirectly discharge through overland, overwater, and groundwater pathways, thereby contributing to chemical contamination of sediments within the Site and to nutrient loading and oxygen depletion in the surface water. Although private industries and municipalities within the river watershed began installing waste control systems beginning in the 1950s, the legacy of past waste management practices remains in the river bottom sediments (LWG, as modified by EPA 2016).

Upstream concentrations of chemicals in the surface water entering the Site already exceed one or more water quality standards, including Oregon and federal water quality standards/criteria for fish consumption, Oregon and federal freshwater chronic aquatic life water quality standards/criteria, and maximum contaminant levels (MCLs). Upstream surface water background levels of arsenic, dieldrin, total PCBs, total PAHs, 4’4-DDT, sum DDT, and 2,3,7,8-TCDD exceeded Oregon water quality standards for fish consumption. Upstream surface water background levels of mercury exceeded Oregon chronic aquatic life water quality standards.

4.2.1.3 Contaminated Sediment Inputs to Surface Water Quality

Lower Willamette River sediment is a known contaminant source that can potentially impact surface water quality through diffusion and advection of pore water containing dissolved chemicals. Mechanical disturbances to sediment from propeller wash or in-water construction, as well as natural erosion and transport, may also result in releases to the water column.

Potential contaminant effects on listed salmonids as a result of sediment resuspension due to a disturbance of the substrate are a function of the chemical, its concentration within the sediment, the environmental conditions at the time of the disturbance, and the duration of exposure. Contaminants become mobilized during sediment disturbance through the release of pore water containing dissolved chemicals, by desorption from sediment, and through loss of particulate bound contaminants (Averett et al. 1999, as cited in Anchor Environmental 2003). Once mobilized, metal contaminants are mostly bioavailable when in a dissolved phase, while organic contaminants can be bioavailable in both dissolved and particulate-bound phases. More specific details related to metal and organic contaminants are provided below.

4.2.1.3.1 Metals

While current Site surface water inorganic and organometalics concentrations are unlikely to pose potentially unacceptable risk to aquatic organisms, including listed salmonids (Windward 2011), area-specific transition zone water (TZW) concentrations of 14 metals (barium, beryllium, cadmium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc) exceeded water TRVs (Windward 2011). Area-specific sediment concentrations of six metals (cadmium, chromium, copper, lead, mercury, and silver) were identified as potentially contributing to benthic toxicity. Desorption of metals from suspended sediments potentially occur within the Site during sediment disturbance.

Different studies have shown that metal concentrations in interstitial (pore) water are correlated with observed biological effects (Ankley et al. 1996, as cited in Anchor Environmental 2003). Under natural conditions, most metals are bound to the sediment because they are associated with particulate matter that has co-precipitated or been scavenged by the iron/manganese oxyhydroxides and carbonates, associated with solid phase natural organic matter, or are bound in the particles of the base mineral matrix. Only a small fraction of metals concentrations are dissolved and available under normal conditions. This description applies to surface sediments in contact with the overlying water and to the depth to which they are oxidized by diffusion or bioturbation (EVS 1997; Hirst and Aston 1983; Slotten and Reuter 1995; all as cited in Anchor Environmental 2003). Deeper sediments are anoxic as a result of microbial degradation of natural organic matter and other oxidation reactions. Under anoxic conditions, the oxyhydroxides dissolve, releasing the metals, but these, in turn, are largely captured by sulfides formed by the reduction of sulfate. In most of these cases, the metals are also largely undissolved and unavailable (EVS 1997, as cited in Anchor Environmental 2003).

4.2.1.3.2 Organics

The focused COCs for Portland Harbor are PAHs, PCBs, DDx compounds, and dioxins/furans, which are all organic compounds with the potential to become resuspended during mechanical sediment disturbance within the Site. Non-polar organic compounds generally are less soluble in water than metals. As such, direct toxicity via organic compounds dissolved in the water column is not as common as metals. However, some organic compounds can bioaccumulate in organisms. This can occur through water column dissolved aqueous phase exposure and from ingestion of organic compounds adsorbed to particulate matter and prey tissue (Windward 2009; Anchor Environmental 2003).

Exposure to dissolved aqueous phase organic compounds can potentially result in adverse effects to fish, including impacts on survival, growth, and reproduction. The draft final BERA found that relatively infrequent and low magnitude exceedances of water TRVs by surface water concentrations of organic compounds in the Site are not indicative of ecologically significant risk to fish. In contrast, exposure to organic contaminants in fish tissues poses potentially unacceptable risks to wildlife and people.

4.2.2 Water Quantity

Habitat access in the Lower Willamette River and the Site is constrained by insufficient water quantity (ODFW 2010; NMFS 2008b). Additionally, the reduced occurrence of peak flows has resulted in decreased channel complexity and habitat diversity in the Lower Willamette River (Bottom et al. 2005; ODFW 2010). Alteration of the hydrograph alters timing and magnitude of flows resulting in impacts on fish habitat (ODFW 2010; Fresh et al. 2005).

The Site is subject to variable (daily [tidal], seasonal, and annual) hydrodynamic forces. The Willamette River is a major tributary of the Columbia River and flows into the river at Columbia RM 103.0. Lowest water in the Willamette, as in the Columbia, typically occurs between September and early November prior to the initiation of the winter rains (U.S. Geological Survey [USGS] 2011). Willamette River flows generally increase in response to regional storms due to the relatively small size of the basin. There are 13 federal reservoirs on the Willamette River and its tributaries, having a combined storage capacity of over 1.6 million acre-feet, along with 43 miles of revetments intended to constrain the meandering of the river (NMFS 2008b). The reservoirs reduce the river flow during the winter snow and rain events by storing water, and the revetments reduce the connectivity of the river to its historical floodplain. With each major storm, USACE is responsible for controlling the amount of water retained and then released at the end of the storm to dampen hydrographic peaks and valleys. During persistent rainy periods and/or during exceptionally large precipitation events, storage capacity may be exceeded, and additional flow entering the system leads to flooding, as occurred in 1964 and 1996.

During these flood events, water flow in the river can be up to 50 times greater than the flow during low-water periods.

The effect of the 13 dams on the Willamette River and its tributaries has generally been to reduce the spring high water flows with retention and storage of water through the system-wide management of reservoirs. Beginning in late summer, stored water is released, which increases flows above the naturally occurring low-flow hydrograph. By winter, these reservoirs have been drawn down, and the storage capacity is used to take the peak off of winter high flows.

Water levels and currents in the Lower Willamette River can be influenced by the Columbia River in several ways. The most apparent influence occurs during spring when high flows from the Columbia River act as a hydraulic dam to the Willamette River, resulting in rises in the Willamette River stage. The Columbia River flow drops as the summer progresses, and this effect is diminished. During the winter, high seasonal flows on the Willamette River can be allowed to pass through to the Columbia River, which may have diminished flows due to retention at dams. This mechanism was used in the 1996 flood to lower the flood stage levels of the Willamette River in Portland. Tidal action also compounds the hydrology and interplay of the two rivers and affects the Willamette River upstream to the Falls upstream of the Site. Tides along the North American West Coast are mixed semidiurnal (two unequal high tides and two unequal low tides daily), with an average tidal range of approximately 8 feet in the Pacific Ocean. The high (flood) tide can influence Willamette River levels by up to 3 feet within the Site when the river is at a low stage. These tidal fluctuations can result in short-term flow reversals (i.e., upstream flow) within the Site during times of low river stage combined with large flood tides. As river stage rises, the tidal effect is gradually dampened and disappears at river levels around 10 feet CRD.

For the water years 1973 through 2007, a 35-year period of record, the mean annual daily discharge of the Lower Willamette River was between 20,000 and 30,000 cfs during 14 years of this period (LWG, as modified by EPA 2016). Annual mean daily flows were above 30,000 cfs during 19 years, with 7 of those years above 40,000 cfs, and 3 in excess of 50,000 cfs. Only two water years (1977 and 2001) had average daily flows between 10,000 and 20,000 cfs (LWG, as modified by EPA 2016).

Overall, water flow in the river is altered by the dams as a result of flood control activities, which creates different flow scenarios than would be expected on an unaltered river system.

4.2.3 Floodplain Connectivity

The Lower Willamette River throughout the Site has been disconnected from its floodplain as a result of urbanization through filling, placement of flood control structures, and development of the riparian zone and floodplain. The floodplain adjacent to the Site has been filled and developed for industrial uses. Between 1850 and 1895, a large percentage of the riparian vegetation along the Lower Willamette River (between Portland and Newberg) was altered or converted to agricultural fields or cities and towns.

By 1990, mixed, hardwood, and conifer forests occupied only about one-third of the riparian area in the lower river (Gregory et al. 2002).

In addition to the changes to the floodplain and riparian areas, the lower river has been deepened and narrowed through channelization, diking, and filling and much of the shallow water habitat has been converted to deep water habitat (Northwest Power and Conservation Council 2004). Whereas historically the Lower Willamette River was dominated by shallow water habitat and approximately 80 percent of the river had depths less than 20 feet CRD, river dredging and alteration has reduced shallow water habitat to nearly 20 percent of the river (City of Portland 2009a). The historical off-channel habitat has mostly been lost due to diking and filling of connected channels and wetlands. The disconnection of the floodplain from the main channel has diminished potential wintering habitat for fish communities (Northwest Power and Conservation Council 2004) and the system's ability to moderate stream temperatures, filter sediments, and supply organics (Northwest Power and Conservation Council 2004).

Overall, the Lower Willamette River has been disconnected from its floodplain throughout the Site due to the factors described above.

4.2.4 Natural Cover

Natural cover is defined as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. Juvenile salmonids need places to hide from predators (mostly birds and bigger fish) in the stream, estuary and nearshore zone such as under logs, root wads and boulders, and beneath overhanging vegetation (Federal Register, Vol. 70, No. 170). Cover provides juvenile salmon with areas of refuge from high, main channel, water velocities, and predators. Studies have found that abundant catches of juvenile Chinook are associated with cover, including undercut banks, vegetated banks, and in-water vegetation (Hillman et al. 1987; ODFW 2005a). Mature, late succession vegetation provides benefits to juvenile salmonids in the form of physical structure. Structure in the form of large wood, when recruited into the active channel, promotes localized scour and pool formation and is itself utilized as cover. Cover is also provided to juvenile salmonids by overhanging vegetation, submerged vegetation, and exposed roots. The cover provided by complexities in structure can increase survival rates for salmonids rearing in summer, overwintering, and outmigrating as smolts (Meehan 1991).

A majority of the area surrounding the Site is developed urban land, and much of the area directly adjacent to the Lower Willamette River is industrial. Consequently, there are limited areas with mature, high quality riparian habitat throughout the Site, and much of the existing riparian habitat is low quality, dominated by invasive species or grasses. The typical bank condition is steep with poor substrate, which results in little to no emergent or submerged vegetation in the project area.

Large woody debris is scattered across the shoreline throughout the Site; however, there are limited areas where large wood aggregates and is persistent. The lack of an existing, mature tree canopy has reduced potential wood recruitment throughout the Site.

Additionally, steep slopes, river channelization, and lack of topographic relief along the shoreline have reduced the potential for wood to be trapped along the shoreline.

Although the natural cover condition within the Site is generally degraded, there are SMA-specific exceptions. For example, beaches adjacent to the Freightliner Corporation along the Willamette side of Swan Island, Kelley Point Park, and Mar Com have limited wood accumulation (LWG, as modified by EPA 2016). Additionally, remnant, fragmented riparian forest patches remain along some portion of the riverbanks and serve to provide as connectivity corridors for various species of aquatic and shorebird species and semi-aquatic mammals to connect to larger areas of wildlife habitat within the proposed action area such as Harborton Wetlands, Oaks Bottom, Forest Park, and Powers Marine Park (City of Portland 2009b).

The LWG mapped areas containing natural cover conditions to show where the PCE exists within the Site at the time of the critical habitat designation (i.e., 2005). PCEs within the Site for freshwater migration and rearing are shown on **Figures 4-1a-k** and **4-2a-k**, respectively. The areas showing the presence of natural cover were identified through aerial photo interpretation as riparian areas with mature trees/shrubs that overhang the ACM and have large woody debris pieces present in an aggregation at the time of the critical habitat designation (i.e., 2005). Although these areas contain the natural cover PCE, based on the criteria used to identify natural cover, the areas are generally degraded as described above. Note that SMA-specific studies completed during remedial design may draw differing conclusions as to the characteristics of the existing habitat.

Based on the mapping exercise, there are approximately 27,500 linear feet of shoreline with existing natural cover PCE. Of this length, approximately 4,600 linear feet (17 percent) of shoreline with natural cover is located within active remediation areas where there is a potential for an impact to occur if a remedial design extends to the riparian area. Potential impacts could be vegetation clearing or some other type of alteration.

4.2.5 Forage

Juvenile salmon and other aquatic species need abundant food sources (forage) to grow and survive. Various aquatic invertebrate surveys, along with a study of juvenile salmonid diets, have been conducted in the Lower Willamette River, and provide information related to the forage condition within the Lower Willamette River. A summary of those studies is provided below:

- Ward et al. (1988) conducted benthic surveys in and around Portland Harbor and found the dominant species to be oligochaetes and cladocerans. The study also commonly found amphipods and chironomids.

- Windward Environmental conducted a survey of the benthic and epibenthic community within the Site and found an abundance of oligochaetes, chironomids, and the amphipod *Corophium* spp (LWG, as modified by EPA 2016).

- A study of macroinvertebrates and zooplankton in the Lower Willamette River using a variety of gear types found an abundance of cladocerans (bosminids and Daphnia), copepods, aquatic insects (including chironomids), and oligochaetes (Friesen et al. 2004).

- In Friesen et al.'s 2005 study, the species diversity in various habitat types was investigated. Overall, the study found few differences in the proportional distribution of major taxa groups among habitat and concluded that the Lower Willamette River is a generally homogenous community (Friesen 2005). Despite this finding, there were general trends that were identified: beaches tended to have relatively high species diversity, whereas seawalls were found to have relatively low densities and diversity. Aquatic insects appeared to prefer rock outcrops and floating structures. Rock riprap sites had very high densities of invertebrates and relatively high diversity (Friesen 2005).

- A 2009 study by SWCA Environmental Consultants (SWCA) conducted benthic macroinvertebrate sampling in downtown Portland. They found an invertebrate community with a similar composition as found in other studies. Specifically, they identified a high abundance of oligochaetes, chironomids, the amphipod *Americorophium* sp, the polychaete *Manayunkia speciosa*, and the clam *Corbicula fluminea*. Salmonids are known to feed on chironomids and amphipods. These species were found at depths ranging from 11 to 79 feet and in substrates ranging from medium silt to medium gravel (SWCA 2009).

- A 2004 salmonid diet study identified the water column invertebrate Daphnia sp. as the most abundant species in the stomachs of juvenile Chinook (larger than 99 mm) and coho by both abundance and wet weight in the Lower Willamette River throughout a majority of the year. These water column species are also in high abundance in the Lower Willamette River. The study also found the amphipod *Corophium* sp. and both aquatic and terrestrial insects to be a common component of salmonid diets (Vile et al. 2004).

These studies documented both water column and benthic salmonid prey items available in the Lower Willamette River across most habitat types, including riprap. The cladoceran Daphnia was found in abundance throughout the Lower Willamette River, although Bosminidae (another cladoceran) was found to be more abundant (Friesen et al. 2004). Physical characteristics, including substrate and water depth, are important in defining benthic forage areas. Fine-grained substrate provides habitat for macroinvertebrates and other benthic organisms, which are juvenile salmonid prey. Shallow water habitats are important for juvenile listed salmonids for foraging because they provide food resources such as benthic macroinvertebrates, zooplankton, and emergent insects (NMFS 2008b).

The LWG mapped areas containing salmonid benthic forage (rearing) conditions to show where the PCE exists within the Site at the time of the critical habitat designation (2005). The areas showing existing benthic forage potential are shown on **Figure 4-2a-k**. SMA-specific studies completed during remedial design may draw differing conclusions as to the characteristics of the existing habitat. Also, water column feeding opportunities exist throughout the Site due to the abundance of Daphnia as previously described. The ACM areas with benthic forage potential were identified as those areas characterized by an unarmored shoreline and small substrate size with no riprap, fill, or debris covering the substrate. The shallow water areas with benthic forage potential were identified as those areas characterized by small substrate size (less than 64 mm), with no debris covering the substrate. Although these areas contain the forage PCE based on the criteria used to identify benthic forage potential, the areas may be impacted by the presence of chemical contamination that limits forage opportunities.

Based on this mapping exercise, there are approximately 70 acres of the ACM and 290 acres of shallow water (0 to 20 feet of water depth from ordinary low water) areas within the Site that contain the forage PCE based on benthic forage opportunities. Of these acreages, approximately 20 acres within the ACM (29 percent) and 100 acres within the shallow water zone (34 percent) could be impacted by active remediation during cleanup.

4.2.6 Artificial Obstructions

Habitat alterations that partially or fully block fish passage constitute barriers to upstream/downstream migration. The proposed action area is within an urbanized area with industrial uses along much of the shoreline. Upstream of the proposed action area, there are 11 multipurpose and two regulation dams operated by USACE (Wentz et al. 1998) that are obstructions to fish passage. However, there are no such obstructions within the proposed action area. Within the proposed action area, there are artificial structures such as docks, pilings, and bridge piers. The effect of these artificial structures, particularly overwater structures, on outmigrating juvenile salmonids is not well understood.

Some studies suggest that overwater structures have the potential to affect juvenile salmonids through habitat changes, increased predation, and disruption of migration patterns (see Nightengale and Simenstad 2001 for a review). However, these studies have not yielded conclusive results. Multiple studies suggest that the movement of juvenile salmonids may be affected by dark/light interfaces cast by overwater structures (Nightingale and Simenstad 2001; NMFS 2004; Southard et al. 2006). Studies have shown that juvenile salmonids may follow the edge of a shadow along piers, rather than pass under the pier. The Pacific Northwest National Laboratory (PNNL) recently conducted a study at 10 Washington State Ferries terminals and found that overwater structures are likely temporary impediments to the movement of juvenile salmonids during specific times of the day or under specific environmental conditions. The specifics depend on light levels, sun angles, cloud cover as well as currents and tidal stage.

Additionally, the study found that “juvenile chum remained on the light side of a dark/light shadow line when the decrease in light level was approximately 85 percent over a shore horizontal distance (e.g.,16.4 feet [5 m])” (Southard et al. 2006). However, in a separate study conducted by PNNL at the existing Mukilteo Ferry Terminal, “salmon fry moved freely under the relatively narrow, shaded portion of the Mukilteo Ferry

Terminal where mean light levels in water were reduced by over 97%" (Williams et al. 2003). Observers concluded that "during the day, fry moved freely under the relatively narrow (33 feet [10 m] wide), shaded portion of the ferry terminal and did not appear to be inhibited by the differences in light levels detected here…the terminal structure did not appear to act as barriers to fry movement at this location" (Williams et al. 2003).

Based on the information summarized above, it is unclear if artificial structures, such as docks and pilings, actually act as an obstruction to migration by causing migration delays. If any delays are realized, it is expected that the delays are minimal and likely do not impact the overall migration rate of juvenile or adult salmonids migrating through the proposed action area.

4.2.7 Other Physical, Chemical, and Biological Indicators Contributing to the Environmental Baseline

4.2.7.1 Shoreline Armoring, Substrate, and Slope

The majority of the Site is industrialized, with modified shoreline and nearshore areas and a uniform channel bottom. The river's banks have been filled and channelized, off-channel areas have been filled and removed, and the river has been disconnected from its floodplain (NMFS 2008b). As a result of the filling, channelizing, and other shoreline modifications that have occurred since the 1850s, steep shoreline slopes are common throughout the Lower Willamette River.

Wharfs and piers extend out toward the channel, and bulkheads and riprap revetments armor portions of the riverbank. The most common bank types occurring within the Site are riprap, sandy and rocky beach, unclassified fill, and seawall. **Figures 4-3a-d** show the shoreline condition within the Site as determined by the LWG shoreline condition line dataset and assumes the shoreline condition extends throughout the active channel margin zone. Note that SMA-specific studies may draw differing conclusions as to the characteristics of the existing habitat. In the Willamette Basin, these types of shoreline hardening alter the velocity and timing of river and streamflows, disconnect rivers and streams from their floodplains, and limit the establishment of native vegetation and the natural maintenance of gravel beds, which has an impact on the character of the substrate in the Lower Willamette River (Willamette Restoration Initiative [WRI] 2004).

In general, with no anthropomorphic impacts, substrate size and location is an indicator of a river's energy regime. Low energy regimes allow for smaller substrates, such as silt and clay, to settle out and build up, whereas high energy environments continually wash smaller sediments away leaving behind larger and coarser substrates such as sand, gravel, and cobble. Much of the Lower Willamette River is dominated by sands. The Lower Willamette River widens between RM 11.0 and 10.0 and allows for a mosaic of sand, silt, and other mixed textures. The finest substrates are located between RM 10.0 and 7.0 where the Lower Willamette River is the widest. Significantly coarser substrates overlaying finer material are found in highly developed areas along the middle and the upper end of the Site (LWG, as modified by EPA 2016). **Figure 4-4** shows the existing substrate conditions within the Site.

Active dredging within the Site to create and maintain the navigation channel has produced a uniform channel with little habitat diversity (LWG, as modified by EPA 2016). Some segments of the Site along the banks and in the off-channel slip areas are more complex, with small embayments, shallow water areas, gently sloped beaches, localized small wood accumulations, and less shoreline development, providing some habitat for local fauna (LWG, as modified by EPA 2016; City of Portland 2009a). The LWG conducted a sidescan sonar review of the Study Area in 2009, which identified scattered debris on the river bottom throughout the Study Area (LWG, as modified by EPA 2016). The debris includes miscellaneous unidentifiable objects, as well as sunken ships, anchors, and steel and wooden piles.

4.2.7.2 Sediment Quality

Chemical groups that pose potentially unacceptable risks in sediments at the Site include PCBs, DDx compounds, total dioxins and furans TEQ concentration, and PAHs (LWG, as modified by EPA 2016). Additionally, there are other "contaminants posing potentially unacceptable risk" as identified in the risk assessments (Windward 2011). Ingestion of fish and invertebrates represents the primary exposure pathway for potentially unacceptable risk to humans and wildlife. Potentially unacceptable ecological risks associated with benthic invertebrates and bioaccumulation in mink, river otter, osprey, hooded merganser, and spotted sandpiper exist throughout the Site. Total PCBs, total PAHs, and pesticide DDT and related breakdown products (collectively known as total DDx) are among the many contaminants associated with toxicity to benthic invertebrates within the Site.

PCBs, dioxins/furans, DDx, and PAHs are the contaminants in sediment that are most likely to pose a potentially unacceptable risk to human health. Bioaccumulation of contaminants in invertebrates and fish may pose a secondary pathway to people and wildlife that consume invertebrates and fish. The risk assessment concluded that PCBs and dioxin/furans in sediment and fish tissue are the most significant contributor to potentially unacceptable risk in the Portland Harbor Site. PAH impacts to benthic invertebrates are also significant, but areas are localized and PAHs do not bioaccumulate in fish or shellfish in concentrations that pose a potentially unacceptable risk to people. Because chemicals in sediment exist in mixtures and areas of high concentrations often overlap, potentially unacceptable risks to other fish, wildlife, amphibians, and plants associated with other contaminants would be reduced or eliminated by sediment remedies that address potentially unacceptable wildlife and human health risks from PCBs, dioxin/furans, DDx, and PAHs.

4.2.7.3 Predation

In a study conducted by Pribyl et al. (2005) in the Lower Willamette River that examined habitat use of piscivorous fish, abundance of predatory fish was disproportionately higher at sites characterized by piles, riprap, and rock outcrops. Radiotagged predatory fish relocated at disproportionately high levels to sites with piles and riprap but were relatively evenly distributed between remaining habitat types. Northern pikeminnow and smallmouth bass were found to use riprap at disproportionately high rates in summer and fall only and at disproportionately low rates in winter and spring when juvenile salmonids are most abundant. Largemouth bass were found at rock outcrops at disproportionately high rates during winter and spring and at piles throughout the year. However, the investigators observed very little evidence of predation on juvenile salmonids. The diets of northern pikeminnow and largemouth bass were dominated by crayfish, and the diets of walleye and smallmouth bass consisted of mainly non-salmonid fish.

Overall, the study concluded that the densities of all large predator fishes are low, and effects on juvenile salmonids are likely negligible. This conclusion is consistent with relatively recent studies conducted by Friesen et al. (2003) and North et al. (2002).

In addition, a 2004 study by Vile et al. found no significant overlap of diet between salmonids and any introduced species. The investigators did find a similarity in diets based on prey taxa abundance between juvenile salmonids and smallmouth bass; however, their diets were dissimilar when evaluated by weight. Daphnia composed 43 percent of the weight of Chinook salmon diets but less than 1 percent of the weight of smallmouth bass diets. The investigators additionally identified that the seasonal abundance of juvenile salmonids and smallmouth bass appear to differ, which reduces the chance for competition. A majority of the smallmouth bass were caught during the summer when juvenile salmonid abundance is lowest (Friesen et al. 2004).

Overall, predation in the Lower Willamette River does not appear to have a significant impact on juvenile listed salmonid species based on the studies summarized above.

4.2.7.4 Habitat Access and Refugia

Habitat access and refugia in the Lower Willamette River has been significantly impacted since the late 1800s. As stated earlier, approximately 79 percent of the shallow water habitat has been converted to deep water habitat within that time period. As a result, species that prefer slower water velocities, foraging opportunities, and cover and refugia provided by shallow water habitat, such as otter, mink, and juvenile salmonids, are confined to narrow strips of shallow water habitat between the shoreline and navigational channel. Subyearling listed salmonids are particularly dependent on shallow water habitats, as the reduction in river velocity allows for significant energy reductions during migration and provides more effective feeding opportunities (NMFS 2007). There are several shallow water habitat pockets remaining in the Lower Willamette River, including Willamette Cove, Swan Island Lagoon, the mouth and channel of Multnomah Channel, and the Sauvie Island shoreline (LWG, as modified by EPA 2016).

A map showing the existing water depths within the Site is shown on **Figures 4-3a-d**. In general, due to the absence of sufficient shallow water habitat, habitat access and refugia are poor within the Site.

4.3 LOWER COLUMBIA RIVER WATERSHED CONDITIONS

The proposed action area includes the Lower Columbia River, downstream of the mouth of the Willamette River to near St. Helens, Washington, and upstream to the confluence with the Sandy River. In addition, an area within the navigation channel is also included as the potential transport corridor if dredged material is transported to a transloading facility close to an undetermined upland disposal site in either eastern Oregon or Washington.

Historically, the Lower Columbia River was a dynamic system providing diverse feeding and resting habitat for juvenile salmonids. The river system delivered sediment and large woody debris to form low-velocity marshlands and tidal channel habitats (Bottom et al. 2005). Intense development and human activity between 1930 and 1970 has significantly degraded the Lower Columbia River, including increased urbanization and the development and operation of the Federal Columbia River Power System dams. Dams, levees, dikes, dredging, and the construction of roads and railways within the Lower Columbia River have significantly reduced the river's habitat opportunities and weakened the river's hydrologic connection with its floodplain. With the loss of 84,000 acres of historical floodplain, the frequency and magnitude of hydrologic events has been altered (NMFS 2008b, 2011b). Additionally, water diversions in Oregon have reduced tributary flows, further altering the flow patterns (Northwest Power Planning Council Northwest Power Planning Council [NPPC] 1992 as cited in NMFS 2011b). Historical annual spring freshet flows were on average 75 to 100 percent higher than the current flows, and historical winter flows were approximately 35 to 50 percent lower than current flows (NMFS 2011b). This reduction in flow variability has greatly reduced sediment and large woody debris transport and habitat complexity. The Lower Columbia River lost approximately 43 percent of its tidal marsh and 77 percent of its historical tidal swamp habitats between 1870 and 1970 (Thomas 1983 as cited in NMFS 2008b).

Habitat degradation in the form of reduced flow and reduced estuary area poses risks for juvenile anadromous fish. Due to reduced spring flows, juveniles are faced with longer migration routes and increased exposure to predation, high temperatures, and various other environmental stressors (NMFS 2008b). The reduction in low energy, off-channel estuary habitat has reduced rearing habitat for Pacific salmon and steelhead (NMFS 2011b). Additionally, various issues were identified by the Oregon Watershed Enhancement Board as issues in the Lower Columbia River, including accumulation of fine sediments from farm and forest roads, passage barriers, and impaired low-gradient stream complexity (Oregon Water Enhancement Board [OWEB] 2006 as cited in NMFS 2008b). The habitat that does remain is a narrow bank of tidal marsh and swamp habitat along the Lower Columbia River, its tributaries, and around undeveloped islands (NMFS 2008b).

The urbanization that accounts for the reduction in habitat area has simultaneously led to degraded water quality in the Lower Columbia River. Agricultural and industrial practices, as well as road and highway development, led to fertilizers, pesticides, and heavy metals entering and contaminating the Lower Columbia River (DEQ 2007a as cited in NMFS 2011b). Road and highway development specifically can result in runoff with pollutants such as copper, zinc, and PAHs.

The DEQ 303(d) list specifies that the Lower Columbia River in the proposed action area as water quality limited for temperature (in the summer months), DDT, PCBs, and arsenic (DEQ 2012). The Lower Columbia River is on the Washington State Department of Ecology (WDOE) 303(d) list for dissolved oxygen, temperature, total dissolved gas, and fecal coliform (WDOE 2008). Additionally, total maximum daily loads (TMDLs) for dioxin and total dissolved gas have been approved by EPA in the Lower Columbia River (DEQ 1991, 2002).

5.0 EFFECTS OF THE ACTION

This section describes the potential effects of the proposed action on ESA-listed species and their designated critical habitat. Direct and indirect impacts as well as interrelated, interdependent, and cumulative impacts are described as applicable to the proposed action. The potential effects associated with the remedial activities are discussed in this section relative to the general baseline conditions found within the action area. The specific effects of each individual remediation project may vary by the specific action and location.

This section describes the short-term effects that would occur during construction of the proposed action as well as long-term, permanent effects on habitat that would occur in some instances. Adverse effects would be avoided or minimized to the extent possible through design criteria that avoid or minimize impacts and implementation of impact avoidance and minimization measures (described in Section 2.5). For instance, effects on shallow water habitat (0-20 feet from ordinary low water) would be avoided by minimizing changes to slope and elevation and placement of beach mix, consisting of rounded gravel typically 2.5 inches or less that provides appropriate substrate for colonization by benthic organisms. When adverse effects cannot be avoided, compensatory mitigation would be required, as described in Section 5.1.13.

The effects analysis presented in this section evaluates effects of the proposed action within the Portland Harbor Site (Lower Willamette River) portion of the action area and in the Lower Columbia River portion of the action area. In the Lower Willamette River, the proposed action includes implementation of remedial technologies (described in Section 2) to address concentrations of contaminants in sediment and riverbank soils, and disposal of contaminated sediments in a CDF.

In the Lower Columbia River portion of the action area, proposed activities include offloading contaminated sediments near shoreline areas if transported for upland disposal and construction of compensatory mitigation projects, the locations of which have not yet been identified. Compensatory mitigation projects would be constructed within the watershed where the impact occurred (DSL recommends that mitigation banks provide credits for impacts in the fourth level hydrologic unit watershed).

The determination of upland disposal facilities locations will occur during the remedial design phase. Options identified in the FS include several Subtitle C and D landfills located upstream of the Site on the Lower Columbia River. As a result, the area where potential direct and indirect effects could occur includes the federally authorized navigation channel transport corridor down the Willamette River to the Columbia River, and upstream on the Columbia River to a potential transloading facility, and in the vicinity of the transloading facility. It should be emphasized that no in-water work or discharge of any material (water, solid, or otherwise) will occur in the transport corridor.

5.1 DIRECT AND INDIRECT EFFECTS TO SALMONID SPECIES IN THE LOWER WILLAMETTE RIVER

In-water work would occur between approximately July 1 and October 31, when ESA-listed fish are expected either to not be present or be present in very low numbers in the action area. During this time, juvenile Chinook salmon and steelhead from the Upper Willamette River ESUs/DPSs, the Lower Columbia River ESUs/DPSs, and Lower Columbia River coho salmon ESU, the more sensitive and vulnerable life stage, may be present in the action area. However, densities of juvenile salmonids are lower in the summer months compared with the winter months, and the summer in-water work window avoids peak smolt out-migration and peak adult migration for both Chinook salmon and steelhead (Friesen 2005). During the proposed in-water work window, it is likely that juveniles will be rearing in small numbers in the action area, upstream migrating Chinook adults are likely to be present in July and upstream migrating coho adults are likely to be present in October.

Adult salmonids would be moving quickly through the action area in the Lower Willamette River and are not expected to spend more than 2 days in the Lower Willamette River based on migration studies, as described in Section 3. Subyearling Chinook salmon are found within the Site throughout a majority of the year, including in small numbers between the beginning of July and the end of October. Smaller subyearling fish (30 to 70 mm) would be more shoreline oriented and spend more time within the action area than larger subyearling fish, which may spend as little as 4 days, based on tagging studies. As described in Section 3, the specific length of time individuals spend within the Site is unknown due to difficulties in tagging such small fish. However, their presence in the action area is assumed.

5.1.1 Water Quality

Overall, water quality conditions in the Lower Willamette River portion of the action area will not change in the long term as a result of the proposed action due to the fact that water quality within the Site is mainly determined by upstream water quality coming into the Site, as described in Section 4. However, the remediation of areas of contaminated sediment and the control of known upland sources to river sediments will result in substantial decreases in, or removal of, exposure pathways to contaminants in bulk sediment, sediment pore water, and TZW, with some localized positive impacts on surface water. The most significant predicted improvement would be the reduction in fish and invertebrate tissue burdens of PCBs. This would indirectly result in a minimization of exposure and potential adverse effects on higher trophic level organisms (avian and mammalian species, including people). PAH exposure to benthos and demersal fish would also be reduced.

The potential for long-term impacts on surface water quality from the containment of contaminated sediments in a CDF is evaluated in Section 5.1.1.4.

While water quality impacts would be minimized during remedial activities with the implementation of BMPs and avoidance and minimization measures described in Section

2.5, there is potential for short-term localized impacts on water quality, including resuspension of chemical contaminants in the water column, elevated turbidity levels, and lowered dissolved oxygen levels during remedial activities. Each of these effects is discussed in more detail below and summarized in Table 5-1.

5.1.1.1 Exposure to Contaminants during Site Dredging

The primary goal of the proposed action is to reduce the potential exposure of aquatic organisms to chemical contaminants in the sediments. Physical disruption of the contaminated sediments during dredging is necessary to implement the proposed action, which could cause a temporary increase in dissolved phase concentrations of some chemicals in the vicinity of dredging activities resulting from resuspension of contaminated sediments, desorption of the contaminants from sediment particles to the water column, and release of contaminated pore water into surface water. This effect is expected to be most observable when dredging areas with the highest contaminant concentrations in sediments and less observable in areas with relatively low sediment contaminant concentrations. If juvenile salmonids are present in the portion of the action area where dredging is occurring, they could potentially be at risk of exposure. Whether that exposure causes detrimental biological effects depends on the concentration of the chemicals in the water and the duration of exposure. If contaminant concentrations are great enough or if salmonid exposure persists over a long period of time, the potential risk of adverse effects or bioaccumulation of some chemicals increases.

Exposure to contaminants is more likely to occur during dredging activities than any other remedial activity because when contaminated sediments are dredged, some portion of the sediment is resuspended in the water column. During placement of materials associated with capping and in-situ treatment, levels of resuspended sediments are not expected to be as high as dredging because the material is more sandy and is expected to settle quickly (within less than an hour). The other components of the proposed action, including transport and disposal of dredged material, piling removal and reinstallation, and construction of compensatory mitigation projects, are not expected to result in a significant risk of exposure to resuspended chemical contaminants by listed salmonid species.

Based on the BERA, the potential acute exposure of contaminants during dredging at the Site is likely associated with soluble compounds such as benzene, naphthalene, and chlorobenzene, in addition to PAHs, PCBs, and DDx compounds. Once mobilized, these organic contaminants can be bioavailable in both dissolved and particulate bound phases. The length of time that sediments are resuspended plays a critical role in determining the chemical impacts to the water column for dissolved phases (Anchor Environmental 2003). The vast majority of resuspended sediment settles close to the dredge within one hour and only a small fraction takes longer to resettle (Anchor Environmental 2003). Therefore, a majority of the contaminants in the particulate fraction resuspended by dredging may not have time to desorb before they resettle to the sediment bed. If ingested, the particulate bound portion of chemicals can also be toxic or contribute to bioaccumulation of chemicals in an organism's tissue.

The duration of dredging at each SMA will be determined during remedial design and is likely to range from a few days to several weeks in duration. While dredging is to occur during times of minimal salmonid migration, transiting individuals may be exposed to an increase in aqueous contaminant concentrations. Acute thresholds are the most appropriate screening values because dredging activities are generally intermittent throughout the day, and migrating juvenile salmonids likely transit through the Site rapidly (approximately 3 days), limiting the probable exposure timeframe to acute intervals. During remedial actions, salmonids are most likely to be exposed to contaminants in surface water through surface water ventilation. Potential effects to listed salmonids from exposure to these three chemical groups are summarized below.

PAHs

Studies of organic contaminant releases to the water column during dredging have been conducted in the past (Anchor Environmental 2003). Theoretically, the equilibrium exchange can allow for release during the dredging of contaminated sediments, and the concentrations of soluble, available organic compounds in water could increase above ambient levels. However, observations made during field studies indicated that the releases were small in comparison to the effective dilution of the receiving system, and any changes in the water quality were transient, even when grossly contaminated sediments were dredged (Anchor Environmental 2003).

Similar results have been observed for PAHs measured during dredging projects. Monitoring conducted at the ports of Los Angeles and Long Beach show PAH concentrations in the water column that are a fraction of that observed in the sediments (Anchor Environmental 2003). For example, dredge monitoring at Port of Los Angeles showed PAH concentrations that were 4 to 6 orders of magnitude lower than the concentrations measured in the sediments. In sediment core samples, total PAH concentrations ranged from 9 to 52 parts per million (ppm), while water column concentrations ranged from 0.098 to 1.5 parts per billion (ppb) (Anchor Environmental 2003).

Environmental concern has focused on PAHs that range in molecular weight from 128.16 (naphthalene, 2-ring structure) to 300.36 (coronene, 7-ring structure). The physical and chemical characteristics of PAHs generally vary with molecular weight, with lower weight compounds having lower octanol-water partitioning coefficient (Kow) and greater water solubility than higher weight compounds. For the Portland Harbor RI/FS, the typical EPA suite of 34 PAH parent and alkylated homologs were measured. Kow values for this set of compounds range from approximately 3.3 (moderately soluble) to over 7 (highly insoluble) (EPA 2003c).

Exposure to PAHs may result in a range of effects dependent on the specific individual PAH or mixture. In general, the unsubstituted lower molecular weight PAH compounds, containing 2 or 3 rings, may produce significant acute toxicity and other adverse effects to some organisms, but are noncarcinogenic. The higher molecular weight PAHs containing 4 to 7 rings, are considerably less acutely toxic, but many of these compounds are demonstrably carcinogenic, mutagenic, or teratogenic to a wide variety of organisms, including fish and other aquatic life. Because most PAHs are rapidly metabolized, they show little tendency to biomagnify in food chains, despite their high lipid solubility.

The BERA recommended that aqueous PAHs not be considered as COCs presenting potentially unacceptable risk to fish including listed salmonids. However, in some areas within the Site, TZW benzo(a)anthracene, benzo(a)pyrene, and naphthalene concentrations and sediment PAH (multiple) concentrations present a potentially unacceptable risk to benthic invertebrates and fish. No federal or Oregon state water quality criteria for the protection of aquatic life exist for many PAHs, including benzo(a)anthracene, benzo(a)pyrene, and naphthalene. Therefore, the BERA adopted aqueous TRVs from the EPA Tier II benchmarks for these compounds (Windward 2011). Tier II values are generally considered conservative benchmarks for evaluating potential adverse effects to fish, when insufficient acceptable data exist to calculate Tier I ambient water quality criteria (AWQC).

Resuspension of sediments during remedial dredging operations in a few areas could result in water column benzo(a)pyrene concentrations exceeding the alternate acute value of 4 micrograms per liter (µg/L) adopted from the EPA (2003c). This value was calculated from the EPA (2003c) by application of the acute-to-chronic ratio (4.17) to the benzo(a)pyrene final chronic value (FCV). The solubility of benzo(a)pyrene varies with water temperature. Reported values include 1.6 µg/L (May et al. 1983) to 3.8 µg/L at 25°C (EPA 2003c). Dependent on actual Site conditions during dredging activities, it is unlikely that salmonids could encounter dissolved aqueous benzo(a)pyrene concentrations at or exceeding the alternate acute value during migration through the Site because water temperature would not be expected to exceed 25°C.

For those PAHs in which no Tier II value exists, the BERA (Windward 2011) included individual PAH TRVs based on EPA (2003c) FCVs for assessing potentially unacceptable risk from some TZW PAH. However, the application of the EPA (2003c) FCVs as individual compounds is inconsistent with the sum narcosis model EPA (2003c) provided to evaluate PAH toxicity in aquatic exposures. Because the EPA (2003c) PAH FCVs are intended to be applied as a sum of quotients, application of the individual PAH FCVs may over- or under-estimate toxicity. Additionally, evaluating acute exposures using the FCVs provides an additional layer of conservatism. However, effects on juvenile salmonids could occur if water column PAH concentrations produced during dredging occur at acutely toxic levels.

PCBs

PCBs are a group of 209 synthetic congeners that often occur in complex mixtures in sediments. They are stable compounds with low water solubilities, reflected by their high log Kow values, which range from approximately 4.15 to 9.6 (summarized in Eisler and Belisle 1996). Their individual water solubilities and bioavailability to aquatic organisms are influenced by pattern and quantity of chlorine substitution on the biphenyl moiety (Eisler and Belisle 1996). Due to their low water solubilities, PCBs predominantly partition with the sediment and suspended particulate phases in aquatic environments.

PCBs are generally not readily metabolized by invertebrates or teleosts (White et al. 1997), and tend to bioaccumulate in food chains. Acute exposure studies suggest that salmonids are not notably sensitive to a mortality endpoint. The studies vetted and utilized in the derivation of the BERA alternative surface water TRV (Windward 2011), report mean 96-hour median lethal concentration (LC50) values ranging from 2.3 µg/L for largemouth bass (Mircropterus salmoides), 136 µg/L for Salmo species, 1,324 µg/L for Pacific salmonid species (Oncorhynchus sp.), to 10,000µg/L for bloater (Coregonus hoyi) (summarized in BERA Attachment 10; Windward 2011). An independent rainbow trout 7-day exposure study reported comparable results of a 100 µg/L mortality no observed effect concentration (NOEC) and a 500 µg/L lowest observed effect concentration (LOEC) (Koponen et al. 2000). The acute water column concentrations leading to mortality in salmonids are considerably higher than the alternative TRV (0.19 µg/L) used for evaluating potentially unacceptable risk to aquatic organisms (Windward 2011).

Current surface water PCB concentrations at the Site are unlikely to present a potentially unacceptable risk to juvenile Chinook salmon or other aquatic organisms. Due to processes of dilution, any increases in water column PCB concentration are predicted to be temporary and transient. However, effects on juvenile salmonids could occur if water column PCB concentrations produced during dredging occur at acutely toxic levels.

DDx

DDx is comprised of a group of similar synthetic compounds/metabolites (DDT, DDD, DDE, and their isomers) that often occur in varied mixtures in sediments. In aqueous environments, DDx are sparingly soluble with log Kow values, ranging from 5.87 to 6.91. Due to relatively high hydrophobicity, DDx preferentially associates with the sediment or suspended particulate phases where the compounds may persist, recalcitrant to degradation (Agency for Toxic Substances and Disease Registry [ATSDR] 2002). Fish are primarily exposed to DDx through dietary uptake (Hinton et al. 2008) and DDx may bioaccumulate in aquatic organisms/foodchains (EPA 1980).

Because the aquatic DDx AWQC was developed for the protection of aquatic-dependent avian species, the BERA derived an alternative surface water TRV (0.011 µg/L) appropriate for the protection of aquatic organisms. The BERA concluded that DDx not be considered a COC to fish due to the low frequency of tissue and surface water TRV exceedances. However, current TZW concentrations in some specific locations within the Study Area were found to pose potentially unacceptable risk to benthic invertebrates and demersal fish. Sediment concentrations in some specific locations within the Study Area were found to be potentially contributing to benthic toxicity (Windward 2011). Remedial dredging activities may temporarily resuspend contaminated sediments and release DDx contaminated pore water (TZW) into surface waters that exceed the acute water quality criteria value of 1.1 µg/L in limited areas of the Site. While juvenile Chinook salmon may encounter increased aqueous DDx concentrations coinciding with their migration downriver, the exposure likely would be temporally and spatially limited. However, effects on juvenile salmonids could occur if water column DDx concentrations produced during dredging occur at acutely toxic levels.

Summary

Potential exposure to resuspended chemical contaminants is associated with soluble compounds such as benzene, naphthalene, and chlorobenzene, in addition to PCBs, DDx, and PAH compounds in a few potential dredging areas within the Site and their immediate vicinity. The following additional measures are being implemented to reduce this potential risk: 1) the proposed action would take place during the in-water work window when few juvenile salmonids are expected to be in the action area; 2) the remediation would include impact avoidance and minimization measures, including BMPs described in Section 2.5 during construction activities; and 3) water quality monitoring will be required to confirm that water quality standards are being achieved during the remedial activities that disturb the sediment surface (as described in Section 2.5).

SMA-specific actions will be developed during remedial design. Additional contaminant dispersion modeling may be required during remedial design for SMAs with higher levels of contamination to determine potential exposure levels and develop the procedures required to minimize the release of contaminants in the water column.

The timeline for the potential for exposure to resuspended chemical contaminants related to dredging within the Site is expected to occur intermittently during the 4 month in-water work window. Dredging is assumed to occur 24 hours per day and 6 days per week. Based on estimated dredge volumes and production rates and estimated cap material volumes and application rates, in-water construction activities for the proposed action are estimated to take between four to five years to complete.

Additionally there is a small chance that accidental spills from construction equipment could expose fish to contaminants. Along with working within in-water work windows, standard and appropriate material handling and containment procedures and BMPs will be implemented.

In summary, although there may be a potential risk to listed salmonid species from short-term exposure to resuspended chemical contaminants within the Site, the long-term sediment quality improvements associated with the proposed action will lead to benefits to the survival and recovery of the listed species and their critical habitat by addressing and removing a known source of chemical contamination.

5.1.1.2 Turbidity

Dredging has the potential to result in significant adverse impacts related to turbidity and suspended particulate levels in the water column, particularly in near-bottom waters. Mechanical dredging typically has a somewhat higher rate of resuspension and potential for increased turbidity levels than hydraulic dredging, although this is not always the case (Anchor Environmental 2003). BMPs described in Section 2.5 will be employed during dredging to minimize the potential for increased suspended sediment and turbidity levels. Dredging operations will be monitored closely and managed carefully to minimize suspended sediment effects according to the applicable requirements for the proposed action, including any additional conditions imposed as a result of this consultation or additional site-specific consultations with NMFS and standards to be set forth in the CWA Section 401 Water Quality Certification for the project. Turbidity levels will be monitored at the compliance boundary, and activities will be suspended if turbidity levels increase above regulated levels.

The discharge of cap materials, in situ treatment materials, and EMNR sand, as well as the placement of the residuals cover layer in dredge areas (together defined as remediation fill materials) has the potential to result in significant adverse impacts related to turbidity and suspended particulate levels. In contrast to dredging, turbidity increases arising from discharge of remediation fill materials is expected to dissipate quickly due to the low level of organic material and larger grain sizes (e.g., sand/gravel) of the material used (NMFS 2005a). However, some localized short-term increases of turbidity above background river conditions could occur during placement of remediation fill materials. The removal of piles could cause an increase to turbidity and, to a lesser extent, the replacement of piles. In general, dredging has the greatest potential to result in increased turbidity of all the remedial activities; therefore, dredging is the focus of the turbidity effects analysis that follows. Turbidity associated with construction of the CDF is described in Section 5.1.1.4 below.

Turbidity increases due to dredging are typically short term and localized in nature and occur close to the bottom of the water column. Suspended sediment concentrations vary throughout the water column, with larger plumes typically occurring at the bottom, closer to the point of dredging. Even without suspended sediment controls, plume intensity decreases exponentially with movement away from the point of dredging both vertically and horizontally. In addition, increases in turbidity that result from dredging activities are typically of much less magnitude than increases caused by natural storm events (Nightingale and Simenstad 2001).

While turbidity increases during dredging are expected to be limited, short-term, and localized, there could be short-term impacts to listed salmonids present in the work area. The effect of increased turbidity on salmonids depends on the amount and duration of exposure. Salmonids have evolved in habitats with periodic high suspended sediment loads as a result of large storm events or snowmelt runoff. Therefore, adult and larger juveniles may be little affected by such occurrences (Bjorn and Reiser 1991) although these events can produce behavioral effects, such as gill flaring and feeding changes (Berg and Northcote 1985). Some studies have indicated that periodic turbidity equivalent to 23 nephelometric turbidity units (NTUs) can lead to reduced salmonid predation and potentially improve their survival (Gregory 1993; Gregory and Levings 1998).

Many studies have investigated the potential effects of increased turbidity on salmonids from dredging activities and have identified various mechanisms of effect, including direct mortality, gill tissue damage, physiological stress, and behavioral effects. The following paragraphs describe these effects in detail.

Direct Mortality

Direct mortality from extremely high levels of suspended sediment has been documented at concentrations far exceeding those caused by typical dredging operations. Laboratory studies have consistently found that the 96-hour LC50 for juvenile salmonids occurs at levels above 6,000 milligrams per liter (mg/L) (Stober et al. 1981; Salo et al. 1980; LeGore and DesVoigne 1973). However, typical samples collected adjacent to dredge locations (within approximately 150 feet) contain suspended sediment concentrations between 50 and 150 mg/L (Palermo et al. 1990; Havis 1988; Salo et al. 1979).

Based on an evaluation of seven clamshell dredge operations, LaSalle (1988) determined that suspended sediment levels of less than 700 mg/L at the surface and less than 1,100 mg/L at the bottom would represent the upper limit concentration expected adjacent to the dredge source (within approximately 300 feet). This concentration would decrease rapidly with distance due to settling and mixing. Concentrations of this magnitude could occur at locations with fine silt or clay substrates. Much lower concentrations (50 to 150 mg/L at 150 feet) are expected at locations with coarser sediment.

Because direct mortality occurs at turbidity levels that far exceed typical dredging operations, direct mortality from suspended sediment is not expected to occur as a result of the proposed action.

Gill Tissue Damage

Gill tissue damage is a potential physiological impact from elevated turbidity levels. Fish gills are delicate and sensitive to silt particles. As silt enters the gills, fish excessively open and close their gills to get rid of the silt. If irritation continues, mucus is produced to protect the gill surface, which may impede the circulation of water over gills and interfere with fish respiration (Bash et al. 2001).

Studies indicate that suspended sediment concentrations occurring near dredging activity are generally not high enough to cause gill damage in salmonids. Servizi and Martens (1992) found that gill damage was absent in underyearling coho salmon exposed to concentrations of suspended sediments lower than 3,143 mg/L. Redding et al. (1987) also found that the appearance of gill tissue was similar for control fish and those exposed to high, medium, and low concentrations of suspended topsoil, ash, and clay. Based on the results of these studies, juvenile and adult salmonids, if present, are not expected to experience gill tissue damage even if exposed to the upper limit of suspended sediment concentrations expected during dredging. No other activities proposed as part of the action are expected to result in higher turbidity levels than dredging. As such, no additional activities are expected to result in turbidity levels that would cause gill tissue damage.

Physiological Stress

Elevated blood plasma cortisol and glucose levels are indicators of physiological stress. Studies have found that at suspended sediment concentrations above 2,000 mg/L, coho salmon have elevated levels of blood plasma cortisol (Redding et al. 1987). Concentrations near 500 mg/L of suspended sediment for 2 to 8 days also caused stress but to a much lesser degree (Redding et al. 1987; Servizi and Martens 1987). At concentrations between 150 and 200 mg/L in glacial till, there was no significant difference in blood plasma glucose levels. Increases in suspended sediment at a concentration of 53.5 mg/L for a 12-hour period caused physiological stress and changes in behavior in coho salmon (Bash et al. 2001).

These studies indicate that exposure for the upper level of suspended sediment concentrations caused by dredge activities (700 to 1,100 mg/L) in fine silt or clay could cause physiological stress to salmonids if exposure persists over an extended period of time. Continued exposure is unlikely, however, due to the tendency for unconfined salmonids to avoid areas with elevated suspended sediment concentrations (Salo et al. 1980) and the intermittent nature of dredging operations.

Physiological stress may lead to reduced survival rates and other sublethal effects. The stress response itself may compromise the organism's immune system (increasing disease susceptibility), thereby affecting mortality rates (USFWS 1998 as cited in Bash et al. 2001). Additionally, physiological stress in fishes may decrease immunological competence, growth, and reproductive success (Bash et al. 2001). A change in blood physiology is an indicator that a fish is experiencing some level of stress. At the individual fish level, stress may affect physiological systems, reduce growth, increase disease incidence, and reduce ability to tolerate additional stressors. At the population level, the effects of stress may include reduced spawning success, increased larval mortality, reduced recruitment to succeeding life stages and overall population declines. Stress to salmonids can affect the parr-smolt transformation, resulting in impaired migratory behavior, decreased osmoregulatory competence, and reduced early marine survival (Wedemeyer and McLeay 1981 as cited in Bash et al. 2001). However, because elevated levels of suspended solids are expected to be of short duration and intermittent, these effects are not likely to occur. No other activities proposed as part of the remedial action are expected to result in higher turbidity levels than dredging. As such, no additional activities are expected to result in turbidity levels that would lead to physiological stress.

Behavioral Effects

Impacts to feeding disruption and changes in migratory behavior are potentially caused by elevated turbidity (Servizi 1988; Marten et al. 1977). Various studies have indicated that high concentrations of suspended sediment impair salmonid foraging (Bisson and Bilby 1982; Berg and Northcote 1985). At concentrations between 2,000 and 3,000 mg/L, exposed yearling coho and steelhead did not rise to the surface to feed (Redding et al. 1987). However, yearling coho and steelhead exposed to lower levels ranging from 400 to 600 mg/L actively fed at the surface. In these instances, the thresholds at which feeding effectiveness was impaired greatly exceed the upper limit of expected suspended solids during dredging. Potential migratory behavioral impacts are also possible as a result of the proposed action. Whitman and Miller (1982) studied the migration impacts on returning adult salmon in heavily turbid conditions. The study found that despite persistently high concentrations of suspended sediment (7 days of concentrations of 650 mg/L), adult male Chinook could still detect natal waters through olfaction. Although most of these studies found behavioral impacts at TSS levels well above those expected during dredging events, juvenile avoidance behavior may occur at levels associated with dredging mainly in areas close to the dredging activity.

Tolerance tests have subjected juvenile steelhead and coho to continuous high turbidities ranging from 57 to 265 NTUs (Bash et al. 2001). In tanks with mean turbidities of 167 NTUs or higher, no fish were found. Fish were found in tanks with lower turbidities (57 and 77 NTUs) at numbers near carrying capacity (Bash et al. 2001). A mean avoidance of 25 percent was discovered for juvenile coho exposed to a 7,000 mg/L level of suspended sediment (Servizi and Martens 1992 as cited in Bash et al. 2001). The authors estimated that the threshold for avoidance by juvenile coho was 37 NTU. Juvenile coho exposed to a short-term pulse of 60 NTU left the water column and congregated at the bottom of an experimental tank (Bash et al. 2001). When the turbidity was reduced to 20 NTU, the fish returned to the water column (Bash et al. 2001). Overall, a majority of the behavioral effects caused by elevated turbidity appear to impact salmonids at levels greater than those expected to result from the proposed action; however, there may be turbidity levels close to the dredge that may occur would result in juvenile avoidance.

Direct impacts to water column *Daphnia* invertebrate species could result during dredging activities as a result of short-term increases in turbidity that may occur as a result of the project. However, *Daphnia* sp. are expected throughout the water column in many areas of the Site, and impacts resulting from short-term reduced water quality are not expected to be at a level that would affect the abundance of these ubiquitous prey items.

Other remedial activities that would disturb the sediment surface, including placement of capping material, piling removal and reinstallation, construction of compensatory mitigation projects, and sediment sampling as part of the MNR monitoring activities are not expected to cause turbidity increases to a level that is detrimental to salmonids with implementation of avoidance and minimization measures and BMPs as described in Section 2.5.

5.1.1.3 Dissolved Oxygen

During dredging, suspension of anoxic sediment compounds may result in reduced DO in the water column as the sediments oxidize. Reduced concentrations of dissolved oxygen can negatively affect the swimming performance of migrating salmonids (Bjornn and Reiser 1991). The upstream migration by adult salmonids requires swimming over long distances, which requires high expenditures of energy and therefore adequate levels of DO (Carter 2005). Juvenile salmonids are strong active swimmers requiring highly oxygenated waters (Carter 2005). Salmonids may be able to survive when DO concentrations are low (less than 5 mg/L), but growth, food conversion efficiency, and swimming performance will be adversely affected (Bjornn and Reiser 1991). A review of numerous studies reported no impairment to rearing salmonids if DO concentrations averaged 9 mg/L, while at oxygen levels of 6.5 mg/L, “the average member of the community will exhibit symptoms of oxygen distress,” and at 4 mg/L a large portion of salmonids may be affected (Carter 2005). In a review of constant oxygen exposure studies, it was concluded that salmonid growth rates decreased less than 10 percent at DO concentrations of 8 mg/L or more, less than 20 percent at 7 mg/L, and generally less than 22 percent at 5 to 6 mg/L (Carter 2005).

Salmonid mortality begins to occur when DO concentrations are below 3 mg/L for periods longer than 3.5 days (Carter 2005). A summary of various field study results by WDOE reports that significant mortality occurs in natural waters when DO concentrations fluctuate in the range of 2.5 to 3 mg/L. Long-term (20 to 30 days) constant exposure to mean DO concentrations below 3 to 3.3 mg/L is likely to result in 50 percent mortality of juvenile salmonids (Carter 2005).

Salmonids have been reported to actively avoid areas with low DO concentrations, which is likely a useful protective mechanism that enhances survival (Davis 1975 as cited in Carter 2005). Field and laboratory studies have found that avoidance reactions in juvenile salmonids consistently occur at concentrations of 5 mg/L and lower, and there is some indication that avoidance is triggered at concentrations as high as 6 mg/L (Carter 2005).

None of these effects is anticipated to occur during dredging because any reduction in DO beyond background is expected to be limited in extent and temporary in nature. Based on a review of four studies on the effects of dredging on DO levels, LaSalle (1988) showed little or no measurable reduction in DO around dredging operations. In addition, impacts to listed fish due to any potential DO depletion around dredging activities is expected to be minimal for the following reasons: 1) the relatively low levels of suspended material generated by dredging operations (less than 700 mg/L at the surface and less than 1,100 mg/L at the bottom of the water column); 2) counterbalancing factors in the river, such as tidal or current flushing; 3) DO depletion typically occurs low in the water column; and 4) high sediment biological oxygen demand created by suspended sediment in the water column is not common (LaSalle 1988; Simenstad 1988) and is not expected to be an issue at the Site due to limited amounts of organic material expected to be present based on the results of sediment core sampling. As a result, any potential reduction in DO during dredging activities as part of the proposed action is expected to be minimal.

During in-place technology activities, material placed is not expected to result in a change in sediment oxygen demand (and resulting DO reduction) during transport through the water column. There may be minor resuspension at the point of impact of the placed materials; however, this condition is expected to be temporary and localized, and the activity would be monitored by water quality testing.

Based on the above information, during dredging and material placement associated with in-place technologies, DO is not expected to drop to a level that will detrimentally impact salmonids that may occur in the action area. Similarly, other remedial activities that would disturb the sediment surface, including piling removal and resinstallation, construction of compensatory mitigation projects, and sediment sampling as part of MNR monitoring activities, are not expected to cause DO to drop to a level that is detrimental to salmonids.

5.1.1.4 Placement of Contaminants in a CDF

During construction of a CDF berm, the use of coarser material with low fine content for the berm fill will minimize turbidity impacts associated with material placement. As with dredging operations, BMPs described in Section 2.5 will be employed during construction of the CDF to minimize the potential for increased suspended sediment and turbidity levels. After a berm is built, the CDF area would be enclosed from the river such that there would be no in-water work.

The use of a CDF to contain contaminated sediments will not result in long-term impacts to surface water quality, as the CDF will be designed to meet water quality standards in perpetuity, including chronic ambient water quality criteria, fish consumption criteria, and drinking water criteria in consideration of ambient background conditions. Once construction of a CDF berm is complete, the CDF will be fully enclosed from the river, limiting potential water quality impacts during filling. Potential release of contaminated sediments during transport on barges directly to the CDF or to trucks for access to the CDF from the shore would be minimized according to BMPs outlined in Section 2.5.

Construction of the CDF berm will include a weir and outfall structure that will be used to drain water from the CDF as it is being filled with sediment. This structure would consist of a pipe and a weir structure through which effluent, when necessary, will outlet at the waterward face of the containment berm into the Willamette River. During filling, as water within the CDF begins to approach a level at which discharge is necessary, water quality within the CDF will be sampled prior to discharge to confirm that water quality criteria will be achieved at the compliance boundary outside of the CDF.

The CDF will be designed and constructed to prevent release of contaminants and long-term impacts to water quality. Long-term monitoring will include evaluating physical stability of the CDF berm during and following high flow and flood events and groundwater quality monitoring of the CDF and berm. To facilitate groundwater monitoring of the CDF and berm, groundwater wells will be installed during final CDF capping activities.

5.1.2 Water Quantity

The proposed action will not result in significant changes to the water quantity in the Lower Willamette River or Lower Columbia River portions of the action area. The Willamette and Columbia River flood control and power supply systems have extensive external controls on the Lower Willamette River and Lower Columbia River water quantity, and the proposed action will not impact these systems.

HEC-2 modeling was conducted as part of the CDF feasibility analysis to assess the potential impacts of a CDF at Terminal 4 on Willamette River flood stage. The preliminary assessment of potential impacts to the Willamette River showed that the rise in flood stage at and just upstream of Terminal 4 would be negligible and would meet federal and City of Portland criteria (BBL, Inc. 2005).

5.1.3 Floodplain Connectivity

Overall, specific activities associated with the proposed action are not expected to alter floodplain connectivity. The environmental baseline describes the Lower Willamette River action area as disconnected from its floodplain due to urbanization, placement of flood structures, development and conversion of the floodplain to other uses, and the reduction of shallow water habitat and riparian areas. The proposed action is not expected to substantially change this condition. As such, negligible impacts on listed salmonid species are expected to result from the proposed action related to changes in floodplain connectivity in the action area.

5.1.4 Natural Cover

Both beneficial and negative changes to natural cover could result from the proposed action. The environmental baseline section describes much of the natural cover within the Lower Willamette River portion of the action area as degraded. For the most part, the proposed action is assumed to not include activities within the riparian area due to the assumed upper extent of the Site being +13.3 NAVD88 as defined in the FS. This elevation is below the typical vegetation line within the Lower Willamette River, and as such riparian areas providing natural cover are not expected to be impacted by most activities described within the proposed action.

However, remediation of some riverbank areas with known contamination would occur during the proposed action. While most of these riverbank areas are highly industrial and consist of developed areas or steep, armored slopes with blackberry and other non-native vegetation, some areas may support natural riparian cover that would be removed or disturbed during remedial activities. In addition, the construction and use of a CDF would reduce the amount of natural cover if the footprint would cover riparian areas. Following remedial activities, natural cover in these areas would be restored to the extent possible, or compensatory mitigation would be required to offset this impact.

In the short term, increases in turbidity during construction as a result of remedial activities that disturb the sediment surface could result in improved short-term natural cover as the suspended sediments could provide salmonids with protection from predators in the form of cover. No other short-term impacts to natural cover are expected.

5.1.5 Substrate and Forage

Substrate quality and quantity play an important role in the development of a healthy benthic community and benthic forage base for listed salmonids. Simpson et al. (1986) and Bournaud et al. (1998) sampled benthic invertebrates from various freshwater locations in two separate studies. The richness of benthic invertebrates at the sampling stations was generally correlated with substrate type. Heterogeneous substrates (sands mixed with silts) contained the richest fauna. The fewest taxa occurred in fine, well-sorted sand. In silty clay substrates, the presence of at least some sand was necessary for the occurrence of several taxa and the abundance of others. Substrate type (cobble, gravel, sand) did have an effect on the composition of species; however, it is difficult to tell how much of an effect (Bournaud et al.1998).

Both short-term and long-term impacts to substrate and forage could result from the proposed action. Remedial technologies, including dredging, in-place technology activities, removal and reinstallation of piling, construction of compensatory mitigation projects, and sediment sampling associated with MNR monitoring activities, will disturb existing benthic organisms and habitat in different ways as described below.

Recovery times for benthic communities following remedial activities are expected to be on the order of months. The BO for the Lower Columbia River Channel Improvement Project indicates that benthic organisms recolonize dredge locations rapidly (NMFS 2005a). A study completed in the Columbia River estuary indicates that recolonization usually occurs between a few and several months (McCabe et al. 1996, McCabe et al. 1998). NMFS found that maintenance dredging in the navigation channel, as well as the side channels, is likely to temporarily reduce the suitability of the sediment for recolonization by copepods (*C. salmonis)* by reducing the organic matter content of the sediments and altering sediment particle size, and therefore some prey species will be lost. According to the NMFS BO, "these changes in prey availability are unlikely to be of a magnitude or extent that would appreciably diminish forage resources in the action area" (NMFS 2005a). Benthic communities are expected to recover similarly for areas where in-place treatment material is placed.

In some areas, dredging and in-place technology activities could improve substrate and thus forage conditions in areas with existing debris or silt-dominated areas by placing sand or gravel substrate as the final surface material, as described below. Sand and gravel substrates generally produce more complex benthic communities than silt-dominated substrates.

5.1.5.1 Dredging

Dredging activities will temporarily remove the biologically active zone and associated benthic communities. Following dredging, a 1-foot thick sand layer will be placed over the dredged area to cover the exposed surface and isolate any dredge residuals and remaining contaminated sediment. This would not occur within the navigation channel or FMD areas where the placement of sand cover is incompatible with current and future waterway uses. Dredging in nearshore areas would be followed by placement of beach mix, which consists of a mix of rounded gravel 2.5 inches or less to provide appropriate substrate for foraging habitat. This would be conducted such that pre-dredging elevations are not exceeded.

5.1.5.2 Capping and In-situ Treatment

Capping and in-situ treatment options would result in the placement of material on top of the biologically active zone, which likely will smother the existing fauna. Impacts to forage areas are expected to be short term until the benthic community starts to re-establish. Placement of in-situ treatment and EMNR material could have less of an impact than capping since only a 12-inch layer of material will be placed with these technologies. Capping and in-site treatment would not be used in the navigation channel or FMD areas where the placement of materials is incompatible with current and future waterway uses.

As described in FS Section 3.3.3, several types of caps will be implemented in various portions of the Site: engineered caps, armored caps, reactive caps, and armored reactive caps. Engineered caps consist of a sand layer with an additional top layer of beach mix in shallow areas. Armored caps would be needed for erosional areas and would consist of a sand layer with a top layer of armor stone. In areas where contamination can move via groundwater or porewater flow, reactive caps would be needed and would consist of a sand layer mixed with activated carbon, an additional layer of sand on top of the reactive layer, and beach mix at the surface in shallow water areas to provide appropriate substrate for foraging habitat.

Armored reactive caps would be needed to secure reactive caps in erosional areas with an additional layer of armor stone. Reactive caps would also include organoclay in areas where PTW is present and capping is the assigned technology. Organoclay reactive caps would include a low permeability layer consisting of clay (e.g., AquaBlok) on top of the bottom sand layer, followed by more sand, and then armor stone.

The placement of armor as a surface layer on top of an existing sand or gravel beach substrate in the ACM or shallow water area would lead to a long-term impact to benthic communities that were established in the sand/gravel substrate. However, re-deposition of fine-grained material in capped and armored areas is anticipated to occur over time, making the armored areas similar in surface grain size to non-armored areas. Although there could be a direct impact to benthic forage opportunities from the placement of riprap armor, compensatory mitigation projects would replace the lost function related to forage in areas where surface material (e.g. riprap armor) is incompatible with habitat. In addition, placement of the cap material is done to prevent a known source of chemical contamination from continuing, which also improves forage conditions. Overall, the proposed action would result in benefits to habitat.

5.1.5.3 CDF

The construction of a CDF will result in long-term impacts as existing aquatic area available for benthic and water column foraging will become upland. This adverse impact would require compensatory mitigation to replace lost habitat and forage area, as described in Section 5.1.13.

5.1.5.4 Long-term Benefits

Long-term effects are expected to be beneficial for substrate and forage opportunities with the removal of a known source of chemical contamination from the substrate, which will improve the habitat for the benthic community and thus improve benthic forage conditions. In addition, in areas with existing debris or silt-dominated substrate that are dredged or capped with sand/gravel material, the proposed action will result in improved conditions for benthic species.

Additionally, in the long term, removal of the known chemical contamination source improves forage conditions and aids in the recovery of the listed salmonid species. Also, there is some evidence that juvenile Chinook and coho diets may be more tied to water column food webs than they are to epibenthic prey items (ODFW 2005a). Thus, while disturbances to benthic habitat will occur during project activities, due to apparent diet preferences (for Chinook) for water column *Daphnia* sp., it is expected that impacts on juvenile salmonid forage via disturbance of the benthic prey community will be minimal.

5.1.6 Artificial Obstructions

The proposed action will have no effect on artificial obstructions within the Site because there are no artificial obstructions to fish passage within the Site. The environmental baseline section describes the action area as being within an urbanized area with industrial uses along much of the shoreline. Upstream of the Lower Willamette River portion of the action area, there are 11 multipurpose and two regulation dams operated by USACE (Wentz et al. 1998) that are obstructions to fish passage. There are also multiple dams upstream of the Lower Columbia River portion of the action area. However, there are no such obstructions within the action area.

Within the action area, there are artificial structures such as docks and pilings, but the extent to which they obstruct fish migration is uncertain. The FS has assumed that piles and dilapidated structures with low function, permanence, and lifespan will be removed. Major and minor structures with medium to high function, permanence, and lifespan are expected to remain in place. Temporary docks are expected to be relocated to allow access to contaminated material.

The presence of the vessels and equipment required to conduct the remedial activities may have a minor effect on the movement of fish during the four month in-water work window. However, conducting the work during the in-water work window would limit the number of listed species that may be migrating through the work areas.

5.1.7 Shoreline Armoring and Slope

The proposed action may result in changes to shoreline armoring and slope. Shoreline armoring and slope changes can result in impacts on listed salmonid species. Shallow sloped beaches and shallow water areas are known to attract juvenile salmon, especially small subyearling Chinook salmon. In a study conducted in the Hanford reach of the Columbia River (Tiffan et al. 2006), researchers found that the presence of subyearling Chinook increased with decreasing beach slope (lateral). The most subyearlings were observed in areas with a 10 percent slope and decreased significantly when slopes exceeded 30 percent. Altering the physical conditions of the shoreline, through armoring and placement of riprap for purposes of bank stabilization, may alter the local characteristics of natural habitats and may also affect natural channel processes that are essential to habitat creation and maintenance. As a result, the ecological functions of the impacted area can be altered, including the use of these habitats by fish, macroinvertebrates, birds, and other organisms (Sargeant et al. 2004).

5.1.7.1 Dredging

The FS assumed that slopes in nearshore areas would be restored to the existing elevation following remedial activities. If this is not feasible in some areas based on remedial design, compensatory mitigation would be required. As described in the FS Section 3, dredge depths will be based on the RALs designated across the Site for the proposed action. A maximum dredge depth of 15 to 19 feet below the existing elevation is assumed in the FS, and special design and side slope stabilization considerations would be conducted on an area-specific basis during Remedial Design.

Following dredging, a 1-foot thick sand layer will be placed over the dredged area to cover the exposed surface and isolate any dredge residuals and remaining contaminated sediment. This would not occur within the navigation channel or FMD area, where the placement of sand cover is incompatible with current and future waterway uses. In addition, dredging in nearshore areas would be followed by placement of beach mix. Exceptions to this are where armoring is required for erosional areas, as described in the next section.

Excavation of contaminated soils would also occur in certain riverbank areas. Ideally, finished riverbank slopes would be less than 5H:1V; however, current industrial and commercial operations may have structures that preclude obtaining this desired slope following remedial action. Additionally, many of the contaminated river banks extend into upland areas that preclude removal of the contamination to PRGs. Consequently, caps likely will need to be placed on many of these banks. Armored caps are assumed to be placed on riverbanks where the slope exceeds 1.7H:1V and on riverbanks in the main channel that are prone to erosive forces. Vegetation is assumed to be used for riverbanks in off-channel areas that are not prone to erosion and with slopes less than 1.7H:1V.

5.1.7.2 Capping and In-situ Treatment

In shallow areas, placement of capping and in-situ treatment materials would result in an increase in bottom elevations and could have adverse impacts on shallow water habitat. In order to avoid the loss of shallow water habitat, an equivalent cap thickness would be dredged prior to placement to allow for a net zero bathymetry change in shallow areas. The maximum dredge depth will be 3 feet to allow for the assumed thickness of an engineered cap (including a top layer of beach mix) where needed.

In some cases, it may be possible to use capping without the additional dredging in order to increase the amount of shallow water habitat at the Site. This would be evaluated with SMA-specific studies during remedial design. Any impacts on flood rise and impacts from the potential creation of areas that may be dry for portions of the year at low water levels would need to be evaluated.

The placement of engineered caps with riprap armor in shallow water areas where there is currently no armoring would have an adverse impact on shoreline armoring conditions.

This type of capping activity, in the absence of the opportunity to place an overlying layer of finer substrate, would permanently alter shallow water habitat. However, re-deposition of fine-grained material in capped and armored areas is anticipated to occur over time, making the armored areas similar in surface grain size to non-armored areas. In addition, compensatory mitigation projects would replace the lost function related to placement of the riprap surface substrate.

5.1.7.3 CDF

The construction of a CDF would turn aquatic area into upland and impact existing slope and shoreline armoring conditions. According to the 60 Percent Design (Anchor QEA 2011), approximately 14 acres of aquatic habitat would be lost in Slip 1 from construction of a CDF at Terminal 4. Of the 14 total acres of aquatic habitat lost, approximately 1.1 acres, or about 8 percent of the total aquatic habitat, would be in the less than 6-foot depth range. Within this 1.1 acres, over 85 percent is steep sloped, armored with large riprap, and/or covered with overwater structures. Additionally, a total of approximately 2.2 acres would be within the 6- to 20-foot depth stratum, which represents about 16 percent of the total aquatic habitat impacted in Slip 1. Within this 2.2-acre area, approximately 85 percent of the area is either steep sloped, armored with large riprap, and/or covered with overwater structures. A total of approximately 10.7 acres, or about 75 percent of the total aquatic habitat that could be impacted at T4 from construction of the CDF, is in the greater than 20-foot depth range, which is plentiful habitat in the Lower Willamette River.

The CDF berm would be constructed at a 2:1 side slope (as shown in **Figure 2-4**), with the exception of a more gently sloped bench (20 percent or 5:1) on the outside face of the berm that is incorporated into the design to reduce the net loss of shallow water habitat (the zone of water 0 to 6 feet in depth) in Slip 1 (Anchor QEA 2011). In this way, there would be an improvement in the slope and shoreline conditions along the face of the berm compared to the existing steep-sloped shoreline. This would reduce some of the loss of shallow water habitat; however, compensatory mitigation would be required to offset the permanent loss of aquatic habitat that would result from construction of a CDF.

5.1.8 Sediment Quality

Sediment quality in the Lower Willamette River portion of the action area would be improved over baseline conditions as a result of the proposed action. As described in the environmental baseline section, the existing sediment quality in the Lower Willamette River is described as impacted with PCBs, pesticides, metals, dioxins and furans, PAHs, and other contaminants, with four of these contaminants bounding the potentially unacceptable ecological risks: PCBs, dioxins and furans, DDx, and PAHs (LWG, as modified by EPA 2016). The primary objective of the proposed action is to remove or isolate the chemical contaminants from the sediment through dredging and in-situ capping. In addition, creosote treated piling will be replaced with a different piling type, which will remove a minimal source of PAHs to the sediment.

Overall, the proposed action will improve the sediment quality over existing conditions in the Lower Willamette River, which will improve the habitat for salmonid benthic prey items and remove a known source of chemical contamination to the water column where listed salmonids rear and migrate.

5.1.9 Habitat Access and Refugia

Habitat access and refugia could be impacted by the proposed action. The environmental baseline section describes the existing condition of habitat access and refugia in the Lower Willamette River as being significantly impacted since the late 1800s, with approximately 79 percent of the shallow water habitat converted to deep water habitat within that time period. As a result, species that prefer the slower water velocities, foraging opportunities, and cover and refugia provided by shallow water habitat, such as otter, mink, and juvenile salmonids, are confined to narrow strips of shallow water habitat between the shoreline and navigational channel.

There would be short-term limits on access to specific areas from placement of construction barges and/or equipment. However, the location of the construction equipment is only expected to cover a small percentage of the river width and would not substantially impact the movement of listed salmonid species.

5.1.9.1 Dredging

Dredging activities in the ACM and shallow water zones that convert these habitat zones to deep water would further degrade listed salmonid species' access to important shallow water habitats. Although this type of dredging would result in impacts on habitats that are important for listed salmonid species, most areas would be backfilled to grade to avoid permanent impacts. Compensatory mitigation would be required to offset any remaining loss of function associated with this type of habitat conversion.

5.1.9.2 Capping and In-situ Treatment

Placement of capping and in-situ treatment materials in shallow and deep water zones that convert these deep zones to shallower zones would improve the habitat access and refugia conditions within the action area. The amount of improvement associated with the new shallower areas would depend on the surface substrate size as discussed in the substrate and forage section above.

Use of containment technologies in shallow areas would require dredging of an equivalent cap thickness (maximum of 3 feet) prior to placement to allow for a net zero bathymetry change. On riverbanks where the slope exceeds 1.7H:1V and at riverbanks in the main channel that are prone to erosive forces, armored caps would be needed. Vegetation is assumed to be used for riverbanks in off-channel areas that are not prone to erosion and with slopes less than 1.7H:1V.

As with dredging, containment could result in a conversion of silt material to sand and gravel material. The capping materials will provide an improvement over current physical substrate conditions in some locations by replacing anthropogenic debris or large rock with sand and/or gravel. Over time, silt would return to depositional areas, resulting in a negligible to beneficial overall impact on the physical characteristics of the substrate.

5.1.9.3 CDF

Construction of a CDF for disposal of dredged material would also convert existing aquatic area to upland, which would further degrade salmonid habitat access and refugia. As described above, approximately 14 acres of aquatic habitat would be lost in Slip 1 from construction of a CDF at Terminal 4 (Anchor QEA 2011). Of the 14 total acres of aquatic habitat lost, approximately 1.1 acres, or about 8 percent of the total aquatic habitat, would be in the less than 6-foot depth range. Additionally, a total of approximately 2.2 acres would be within the 6- to 20-foot depth stratum, which represents about 16 percent of the total aquatic habitat impacted in Slip 1. A total of approximately 10.7 acres, or about 75 percent of the total aquatic habitat that could be impacted at T4 from construction of the CDF, is in the greater than 20-foot depth range, which is plentiful habitat in the Lower Willamette River.

5.1.10 Predation

Overall, the proposed action will not result in changes in predation on salmonids. However there is the potential that the placement of the rock armor layer as a part of engineered capping may improve habitat for fish that could prey on juvenile salmonids. However, native and introduced piscivorous fishes in the Lower Willamette River do not appear to prey significantly on juvenile salmonids. Ward et al. (1994) detected no difference in the frequency of northern pikeminnow (*Ptychocheilus oregonensis*) stomachs containing juvenile salmonids between developed areas of the Portland Harbor containing riprap and undeveloped areas. As such, the proposed action is not expected to impact predation on salmonids.

With the removal of some piles and dilapidated structures, predation on juvenile salmonids by piscivorous birds may decrease, which would be a beneficial effect on salmonids.

5.1.11 Other Potential Effects

5.1.11.1 Entrainment or Contact with Construction Equipment

In-water work will take place during the in-water work windows, and BMPs will be implemented to reduce the potential for fish to be entrained or come in contact with construction equipment. In general, fish that are present within work areas during construction would be expected to avoid or rapidly move away from construction areas and other locations of active disturbance. However, entrainment in the dredge equipment during remediation is a potential direct impact to listed salmonid species, as described below.

During mechanical dredging, pressure waves created as the bucket descends through the water column are expected to forewarn salmonids present within the area and allow individuals time to avoid the mechanism. In addition, the clamshell jaws will be open during descent, which should reduce the likelihood of entrapping or containing fish

(NMFS 2003). USACE conducted extensive dredge entrainment monitoring within the Columbia River in 1985 through 1988 (Larson and Moehl 1990). In the study, no juvenile salmon were entrained in mechanical dredging equipment. McGraw and Armstrong (1990) examined fish entrainment rates due to mechanical dredging outside of peak migration times in Grays Harbor from 1978 to 1989 and found that one juvenile salmon was entrained.

Hydraulic dredging will remove sediment at or below the surface of the bed material being removed. The hydraulic dredge head may be raised briefly to a maximum of 3 feet above the surface to flush the intake system. However, operational procedures and BMPs will reduce the likelihood of entrainment when the hydraulic dredge head is lifted out of the substrate. Based upon a methodology that was developed to estimate the magnitude of take as a result of hydraulic maintenance dredging operations on the Lower Columbia River up to RM 125.3, NMFS found that “the magnitude of effect on ESA-listed juvenile salmonids from entrainment is likely to be small at the population and ESU scales” (NMFS 2005a). In the Northwest Aggregates BO for the removal of material by hydraulic dredging in the Lower Columbia River, NMFS concluded that injury or death to listed salmonids as a consequence of entrainment is expected to be minimal based on timing restrictions for shallow water work, BMPs for placement of the draghead during dredging, and the fact that salmonids can usually avoid dredging activities (NMFS 2005c).

Silt curtains and sheet piling may be used in localized areas to prevent migration of highly contaminated sediment during dredging or during disposal operations. Entrainment during these activities would be avoided with the implementation of the fish capture and removal measures in coordination with NMFS and other agencies, as appropriate, as described in Section 2.5.

During construction of a CDF, entrainment of fish behind the isolation berm or structure is also possible. To avoid trapping any fish, fish would be removed or excluded from the work area. The strategy for fish removal will be determined during remedial design, but is likely to be conducted with the use of electrofishing, beach seining, purse seining, and fyke nets. These removal activities could lead to injuries to listed fish species. However, the berm construction would take place during the in-water work window to minimize the number of listed species that may be in the work area. In addition, fish capture and removal measures would be implemented prior to these activities. These measures are described in Section 2.5.

Entrainment of juvenile salmonids is also possible during the efforts associated with capturing resident fish species for tissue sampling and analysis activities associated with the MNR monitoring. However, this activity will be conducted during the in-water work window, which will minimize the number of juvenile salmonids that would be present during the fish capturing activities. In addition, implementation of the fish capture and removal measures described in Section 2.5 will avoid impacts on ESA-listed species.

5.1.11.2 Noise

Overall, the activities associated with the proposed action, except piling removal and installation, are not expected to create a noise impact on aquatic species. Construction noise is not likely to increase noise levels above ambient levels in water and out of water. However, in-water noise could be elevated as a result of pile installation activities. Pile driving activities are proposed in the Lower Willamette River and salmonids could potentially be present during the installation activity. It is assumed that pile driving operations will use the vibratory hammer method. If impact pile driving is proposed, it will be evaluated on an SMA-specific basis during remedial design.

Vibratory pile driving produces noise levels that are less than those generated during impact pile driving (WSDOT 2015) under similar conditions. Noise from the vibratory hammer installation of piles has not been found to cause barotraumas to fish (physical injury documented to result from impact pile driving) because the vibratory pile extractor noise does not have the rapid-rise peak pressure that is characteristic of impact pile driving (WSDOT 2015). As such, no measurable effects on salmonids are expected to result from vibratory pile removal or installation activities.

To further minimize any potential for impacts to result from vibratory pile removal and driving activities, pile driving will be conducted within the in-water work window approved for the protection of salmon such that listed salmon would not be present in appreciable numbers at any given time. Additional impact avoidance and minimization measures would be implemented, as outlined in Section 2.5. Therefore, adverse effects from pile driving activities would be reduced to the maximum extent possible.

5.1.11.3 Effects from Use of Activated Carbon

Several studies have examined the potential adverse effects to aquatic species, especially benthic invertebrates, from the use of activated carbon (AC) in capping and in-situ treatment materials (Cho et al 2009; Ghosh et al 2011; Beckingham et al 2013; Jonker and van Mourik 2014). End points of survival, lipid content, and growth of benthic invertebrates have been measured. Results of these studies have been varied, with some field and laboratory studies reporting detrimental effects and others showing no observable detrimental effects. For instance, Cho et al. (2009) summarized several field studies of the application of AC amendment, which reported no adverse impacts to the existing macro benthic community composition, richness, or diversity (Cho et al 2009).

In addition, Ghosh et al (2011) found that field testing at Hunters Point in San Francisco Bay, which had an AC at 2 to 5 percent by weight of dry sediment did not show a significant impact on the benthic community as judged by the diversity of species and their overall abundance. In their review, Janssen and Beckingham (2013) reported varying results of several studies of effects to the benthic community from the application of AC to sediments. In some cases, the benthic community was robustly recolonized where AC ranged from 2 to 10 percent, with the composition impacted only in terms of abundance of two relatively sensitive taxa. However, at other sites, reduced abundance was observed for different AC caps, although the caps consisted of a thin layer of material(s) translating to an AC dose of up to 40 percent, exceeding the conditions of the other studies.

Some studies have reported decreased lipid content in benthic organisms, as summarized by Beckingham et al. (2013). Their review found that of 18 studies covering 82 tests of AC amendments, about 72 percent of all tests did not show an effect (neither positive nor negative) on the health of the organisms relative to exposure to untreated sediment. Negative effects were most frequent for changes in growth (6 percent), followed by lipid content (5 percent), and behavior (5 percent), and were least frequent for survival (2 percent). In general, most negative effects appear species-specific and are more prominent for amendments to unpolluted sediment and with higher AC dose and finer AC particle size. For instance, AC amendment impacted the survival of three filter feeding species out of 17 species tested and affected the lipid content of two burrowing worms out of seven species tested. Fine-grain AC affected lipid content and growth more strongly than coarser AC (Beckingham et al. 2013). It has also been found that repeated and longer periods of disturbance, for example, staggered amendments or mechanical mixing, may lead to an extended recovery time for the benthic community (Janssen and Beckingham 2013). In addition, adverse effects of AC on benthic organisms could originate from reduction in the availability of trace nutrients, which may be replenished more easily in actual field applications than in laboratory settings, although nutrient flux from sediment is not well understood (Janssen and Beckingham 2013).

In addition, reduced growth in submerged aquatic plants in the laboratory was observed at or above 5 percent by dry weight AC (Beckingham et al 2013). However, Kupryianchyk et al. (2012) did not find an effect on composition or density of macrophytes up to 15 months following amendment with up to 10 percent by dry weight AC.

While adverse effects to the benthic community would reduce forage opportunities for many species of fish and other aquatic organisms, including listed salmonids, adverse effects from AC directly to fish are limited, as evidenced by the wide-spread use of activated carbon in aquaria. However, Jonker and van Mourik (2014) noted that based on laboratory tests, AC effectively binds to fish pheromones, potentially resulting in effects to fish behavior. They conclude that more study with field application is needed.

In summary, adverse effects to benthic invertebrates or other aquatic species from the use of 5 percent or less AC in capping or in-situ treatment materials appear to be limited. AC works primarily by retarding contaminant transport through the cap and acting as a barrier between the contaminated sediment and the new benthic layer, thus preventing exposure of the benthic and pelagic communities to the contaminants. This would be a significant benefit to listed salmonid and other aquatic species in the Lower Willamette River.

5.1.11.4 Effects to Pacific Lamprey Ammocoetes

Pacific lamprey ammocoetes may be present in sediments year-round in the action area, particularly in depositional areas such as in low velocity pools and stream margins.

Ammocoetes are particularly vulnerable to remedial activities such as dredging and capping that would be implemented under the proposed action.

USFWS has recommended BMPs be implemented prior to dredging, capping, and other sediment disturbance to avoid and minimize impacts to lamprey ammocoetes in accordance with a Conservation Agreement between local tribes, states, federal agencies, non-governmental organizations, and other stakeholders (USFWS 2012). As described in Section 2.5, these recommendations include electrofishing surveys for the presence of lamprey ammocoetes prior to construction.

5.1.12 Effects on the Critical Habitat PCEs for Pacific Salmonids

The action area is used by Pacific salmonids for juvenile rearing and migration to and from natal streams. Critical habitat has been designated in the Lower Willamette River for the Upper Willamette River ESUs/DPSs and the Lower Columbia River ESUs/DPSs of Chinook salmon and steelhead. In addition, critical habitat is proposed for coho salmon in the Lower Willamette River.

Rearing and migration PCEs identified as critical habitat for salmonids inhabiting the Lower Willamette River are based on several components of habitat structure. The rearing PCE can be subdivided into two categories: cover/refugia and forage. Juvenile salmon need abundant food sources (forage) as well as places to hide (cover) from predators (e.g., birds and bigger fish) such as under logs, rootwads, and boulders and beneath overhanging vegetation. They also need places to seek refuge (refugia) from periodic high flows and from warm summer water temperatures (NMFS 2005c). The specific habitat characteristics required to support the rearing PCE include water quality, water quantity, floodplain connectivity, natural cover, and forage.

Freshwater migration PCEs for juvenile and adult salmon require migration and movement corridors (connectivity) with adequate passage conditions (water quality and quantity available at specific times) to allow access to various habitats required to complete their life cycles (NMFS 2005c). The specific habitat characteristics required to support the freshwater migration PCE include water quality, water quantity, and (lack of) artificial obstructions.

As described previously, the proposed action would result in effects to these habitat characteristics and to salmonid PCEs in the lower Willamette River portion of the action area. **Table 5-1** summarizes the effects to salmonid PCEs compared to the environmental baseline described in Section 4. These effects are summarized below:

Freshwater Rearing PCE:

- Water Quality – The proposed action will result in the removal or isolation of contaminated sediments, which are a known source of contamination to the water column as well as to benthic invertebrate prey items that bioaccumulate contaminants directly. Short-term effects on water quality will occur related to remedial activities that disturb the sediment bottom, but turbidity is expected to be limited, short term, and localized, and is not expected to result in any long-term effects. Resuspension of contaminants may occur during in-water work in a few areas and the surrounding vicinity, but salmonids would not be expected to be present or would be present in very low numbers. Additionally, if present, they would not be expected to experience substantial effects because the area of exposure would be minimized through the implementation of impact avoidance and minimization measures, which would be monitored through water quality monitoring during construction.

- Water Quantity – The proposed action is expected to have negligible effects on water quantity or flows.

- Floodplain Connectivity – Floodplain connectivity is already limited in the proposed action area by industrial activities and urbanization and will not be altered due to the proposed action.

- Natural Cover – The environmental baseline section describes much of the natural cover within the Lower Willamette River portion of the proposed action area as degraded. However, approximately 27,500 linear feet of shoreline has existing natural cover PCE based on aerial photograph interpretation, which would be updated based on SMA-specific surveys during remedial design. Of this length, approximately 4,600 linear feet (17 percent) occur within an active remediation area that could alter riparian vegetation during the cleanup if the cleanup activities extend above +13.3 NAVD88. The amount of riparian vegetation that occurs within proposed riverbank areas where construction would occur has not yet been identified. In addition, construction of CDFs would include riparian areas within the footprint of the CDF.

- Forage – As described in the environmental baseline section, there are approximately 70 acres of the ACM and 290 acres of shallow water areas (0 to 20 feet of water depth from OLW) within the Study Area that contain the forage PCE based on benthic forage opportunities. Of these acreages, approximately 20 acres within the ACM (29 percent) and 100 acres within the shallow water zone (34 percent) could be impacted by active remediation during cleanup. Note that these areas could be updated based on SMA-specific surveys during remedial design.

Freshwater Migration PCE:

- Water Quality – same as above

- Water Quantity – same as above

- Natural Cover – same as above

- Free of Artificial Obstructions – The proposed action may have a beneficial impact on artificial obstructions within the Site as piles and structures may be removed and not replaced.

5.1.13 Compensatory Mitigation

Remedial activities in shallow water areas would be conducted in a manner that minimizes permanent habitat loss to the extent possible by restoring elevation, slope, and substrate. However, in some areas, long-term adverse effects on salmonid PCEs would occur and require compensatory mitigation. These effects are summarized as follows:

- Natural Cover: While very limited in the action area, some riverbank areas may support natural riparian cover that would be removed or disturbed during remedial activities, and it may not be possible to restore natural cover on site in all of the areas where it is disturbed.

- Substrate and Forage: Some areas of existing sand or gravel may be permanently lost with the placement of engineered caps that use riprap armor as a surface layer, and where placement of beach mix as a top layer is not possible.

- Shoreline Armoring and Slope: As described above, some armoring would occur in shoreline areas, and it may not be possible to restore ideal slopes.

- Habitat Access and Refugia: In some areas, dredging may be required to a depth such that shallow water would be converted to deep water and/or there would be loss of shallow water habitat complexity, reducing the amount of shallow water habitat and refugia available.

- CDF: At the proposed Terminal 4 CDF location, approximately 14 acres of aquatic habitat would be converted to upland, resulting in permanent loss of aquatic habitat. Of the 14 total acres of aquatic habitat lost, approximately 3.3 acres, or about 24 percent of the total aquatic habitat, would be shallow water habitat (less than 20-feet deep).

Section 404(b)(1) of the CWA requires that the proposed action be designed to avoid or minimize adverse impacts to aquatic resources and waters of the United States. The Section 404(b)(1) evaluation is presented in a separate document and is broader than the effects evaluation presented in this BA. While the evaluation presented in this BA is based primarily on effects to habitat for listed salmonids, the key habitat characteristics important to salmonids are also important to many other aquatic species, as described in the 404(b)(1) evaluation.

Compensatory mitigation requirements will be determined based on comparison to what is recognized as the highest functioning habitat for salmonids. Highest functioning habitat includes shallow water areas with a gentle slope (shallower than 5:1), with sand and gravel substrate, and with complex habitat in the form of accumulated large woody debris. A mitigation approach was developed in coordination with NMFS that is based on a Habitat Equivalency Analysis (HEA) method. HEA compares existing habitat functions to proposed habitat functions (after remediation) within the same area using relative habitat values (RHVs). The difference between existing and proposed function represents either an increase in ecological function (mitigation credit) or a decrease in ecological function (mitigation debit that would require compensatory mitigation).

The HEA method quantifies wetland resources using RHV scoring developed by the Portland Harbor Natural Resource Trustee Council and NMFS (PHNRTC 2010). Habitat characteristics include type and extent of riparian habitat, slope and substrate of the active channel margin, depth and substrate of the main channel area, and characteristics of off-channel habitat. RHV scores developed for the Site are shown in **Table 5-3**.

To score existing habitat condition, geographic information system (GIS) information for water depth, substrate type and shoreline complexity (slope and large woody debris), and riparian vegetation will be evaluated for each of the SMAs during remedial design. Post-remedial action habitat condition would be assessed in the same manner, and the difference in scores would be used to estimate the acres of compensatory mitigation that would be required.

During Remedial Design, the compensatory mitigation approach described above would be used once the remedial action is fully defined and avoidance and mitigation measures are fully developed for each SMA. Additional SMA-specific data collection would be conducted as needed to supplement existing data in order to quantify existing and proposed habitat conditions. During Remedial Design, use of the HEA method and RHV scoring approach would be verified through consultation with NMFS.

It is assumed that compensatory mitigation projects would be constructed in the Lower Willamette River and/or the Lower Columbia River. These projects would entail the conversion of existing upland habitat to shallow water habitat with sand/gravel substrates, shallow slopes, and shoreline complexity.

5.2 DIRECT AND INDIRECT EFFECTS TO ESA-LISTED SPECIES AND DESIGNATED CRITICAL HABITAT IN THE LOWER COLUMBIA RIVER

Species that would only be present in the Lower Columbia River portion of the action area include Columbia River chum salmon, green sturgeon, and eulachon. Bull trout are also present in the Lower Columbia River. In addition, southern resident killer whale are included here due to potential effects of contaminant exposure from their salmonid prey.

Within the Lower Columbia River, the proposed action only includes the transport of dredged material to a transload facility and construction of compensatory mitigation projects. Construction of compensatory mitigation projects will only occur during the in-water work window for the Lower Columbia River, which generally extends from November 1 through February 28, annually.

The transport of dredge material along the navigation channel to a transload facility on the Columbia River is not expected to result in adverse impacts to water quality.

Transport of sediments using sealed haul barges would avoid spills into the Lower Columbia River. Any spills or accidental releases of dredged material during offloading of contaminated sediments from barges at the transload facility will be avoided by implementing standard and appropriate material handling and containment procedures as described in Section 2.5.

In addition, the transport of dredge material is not expected to result in adverse effects compared to the environmental baseline conditions related to water quantity, floodplain connectivity, natural cover, substrate and forage, artificial obstructions, shoreline armoring and slope, sediment quality, habitat access and refugia, predation, entrainment, or noise. Therefore, this activity is not discussed further.

5.2.1 Listed Salmonid Species, Bull Trout, and Designated Critical Habitat

Construction of compensatory mitigation projects in the Lower Columbia River would occur in upland areas that would be converted to shallow water areas as part of the mitigation action. During construction activities, such as dredging, adverse impacts on water quality could occur, as described for the Lower Willamette River in Section 5.1.1. However, given the assumed limited extent and duration of construction of individual compensatory mitigation projects in the Lower Columbia River, water quality effects would be short term and localized at the mitigation project site. In addition, the implementation of the avoidance and minimization measures and BMPs described in Section 2.5 would be required.

Potential impacts associated with activities occurring in the Columbia River portion of the action area are not expected to resuspend chemical contaminants because mitigation sites will not be located in areas with contamination. Therefore, there will be minimal risk of exposure of listed salmonid species to resuspended chemical contaminants.

Risk to salmonid species and bull trout in the Lower Columbia River portion of the action area from the dispersion of contaminants during dredging and other remedial activities downstream from the Portland Harbor Site to the Lower Columbia River is expected to be minimal with the implementation of the avoidance and minimization measures and BMPs described in Section 2.5.

Overall, compensatory mitigation projects would have beneficial effects on listed salmonid species in the Lower Columbia River through the conversion of existing upland habitat to shallow water habitat. It is assumed that compensatory mitigation projects would improve substrate and forage habitat with the placement of sand/gravel substrates, shallow slopes, and shoreline complexity. There could also be increased floodplain connectivity and improvement in shoreline armoring conditions (if armoring is removed as a component of the mitigation action). For these reasons, adverse impacts on salmonid or bull trout PCEs in the Lower Columbia River would not be expected from construction of compensatory mitigation projects.

5.2.2 Southern DPS of Green Sturgeon and Designated Critical Habitat

The southern DPS of green sturgeon is present in the Lower Columbia River only. Green sturgeon are a highly migratory fish, and migrating subadult and adults are found in the Lower Columbia River during the summer and fall. Green sturgeon do not spawn in the Lower Columbia River. The proposed action will only occur during the in-water work window. Individuals from the southern population of green sturgeon could migrate through and hold in deeper areas of the Columbia River portion of the proposed action area as subadults or adults, but this is unlikely to occur during the work window. Additionally, it is unlikely that green sturgeon would be found in large numbers within the proposed action area at any time of year.

Construction of compensatory mitigation projects in the Lower Columbia River could have adverse impacts on water quality related to increased turbidity during the short term and limited to the localized area of the mitigation project. Effects to green sturgeon will likely be less severe than those described for salmonids in Section 5.1.1 because salmonids are a more sensitive species. In addition, sturgeon are bottom dwellers and encounter turbid conditions on a regular basis.

Potential impacts associated with activities occurring in the Columbia River portion of the action area are not expected to resuspend chemical contaminants because mitigation sites will not be located in areas with contamination. Therefore, there will be minimal risk of exposure of green sturgeon to resuspended chemical contaminants. Risk to green sturgeon from the dispersion of contaminants during dredging and other remedial activities downstream from the Portland Harbor Site to the Lower Columbia River is expected to be minimal with the implementation of the avoidance and minimization measures and BMPs described in Section 2.5.

Impacts on designated critical habitat for green sturgeon are unlikely to occur. Rather, compensatory mitigation projects are expected to result in long-term benefits from the conversion of existing upland habitat to shallow water habitat with sand/gravel substrates, shallow slopes, and shoreline complexity. As part of the proposed action, construction of compensatory mitigation projects would be required to comply with the impact avoidance and minimization measures and BMPs described in Section 2.5 during construction activities. For these reasons, adverse impacts on green sturgeon or green sturgeon critical habitat PCEs would be negligible.

5.2.3 Southern DPS of Pacific Eulachon and Designated Critical Habitat

Adult eulachon may enter the Columbia River as early as December, or earlier, or as late as May, with the average arrival date in early January. Eulachon spawning in the Sandy River and Columbia River tributaries upstream migrate through the Lower Columbia River portion of the proposed action area, but it is not known at this time whether spawning occurs within the action area. Eulachon may be present during the in-water work window for the Lower Columbia River.

As described above, construction of compensatory mitigation projects in the Lower Columbia River could have adverse impacts on water quality related to increased turbidity during the short term. During construction, adverse impacts on water quality related to increased turbidity would be short term and localized at a mitigation project site. With the implementation of the avoidance and minimization measures and BMPs described in Section 2.5, short-term localized impacts from turbidity would be negligible.

Potential impacts associated with activities occurring in the Columbia River portion of the action area are not expected to resuspend chemical contaminants because mitigation sites will not be located in areas with contamination. Therefore, there will be minimal risk of exposure of listed salmonid species to resuspended chemical contaminants.

Potential impacts associated with activities occurring in the Columbia River portion of the action area are not expected to resuspend chemical contaminants because mitigation sites will not be located in areas with contamination. Therefore, there will be minimal risk of exposure of eulachon to resuspended chemical contaminants. Risk to eulachon from the dispersion of contaminants during dredging and other remedial activities downstream from the Portland Harbor Site to the Lower Columbia River is expected to be minimal with the implementation of the avoidance and minimization measures and BMPs described in Section 2.5.

Overall, compensatory mitigation projects are expected to result in long-term benefits from the conversion of existing upland habitat to shallow water habitat with sand/gravel substrates, shallow slopes, and shoreline complexity. Designated critical habitat for Pacific eulachon relevant to the proposed action area includes the following physical or biological features that are essential for the conservation of the species:

- Freshwater spawning and incubation sites with water flow, quality, and temperature conditions and substrate supporting spawning and incubation

- Freshwater and estuarine migration corridors free of obstruction and with water flow, quality, and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted

As mentioned above, it is currently not known whether eulachon spawning occurs within the Lower Columbia River portion of the action area. It is expected that approved in-water work windows for specific compensatory mitigation projects would consider the most recent information related to spawning activities as well as timing of the peak movement of larval eulachon downstream such that construction during these times would be avoided.

The effects of the proposed mitigation construction on eulachon critical habitat would include short-term impacts to water quality resulting from turbidity during the mitigation site construction and long-term benefits to water connectivity, migratory habitat, shoreline complexity, and substrate. With implementation of avoidance and minimization measures and BMPs described in Section 2.5, adverse impacts on PCEs for eulachon would not be anticipated.

5.2.4 Southern Resident Killer Whale

Southern Resident killer whale survival and fecundity are correlated with Chinook salmon abundance (NMFS 2008c). Southern Resident killer whales have been found to have a strong preference for Chinook salmon during late spring to fall; chum are also consumed in significant amounts. Little is known about winter and early spring dietary preferences (NMFS 2008c).

The presence of high levels of persistent organic pollutants, such as PCBs, have been documented in Southern Resident killer whales. Because of their long life span, position at the top of the food chain, and their blubber stores, killer whales are capable of accumulating high concentrations of fat-soluble contaminants. This contaminant load may be associated with reproductive failure or mortality (NMFS 2008c).

Potential effects on Southern Resident killer whales could occur if their salmonid prey is exposed to contaminants resuspended during the proposed action and bioaccumulate persistent contaminants such as PCBs in tissues that are then consumed by the killer whales at levels that would cause harm. Adverse effects are unlikely for the following reasons:

- The proposed action would take place during the in-water work window when few salmonids are expected to be in the action area.
- The remediation would include impact avoidance and minimization measures, including BMPs described in Section 2.5 during construction activities to avoid and minimize salmonid exposure to resuspended contaminants.
- Water quality monitoring will be required to confirm that water quality standards are being achieved during the remedial activities that disturb the sediment surface.
- The long-term sediment quality improvements associated with the proposed action will lead to benefits for the survival and recovery of listed salmonid species by addressing and removing a known source of chemical contamination, improving this food source for killer whales.
- Compensatory mitigation projects in the Columbia River would improve habitat conditions for salmonid survival and recovery, improving this food source for killer whales.

5.3 INTERRELATED, INTERDEPENDENT, AND CUMULATIVE EFFECTS

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification (50 CFR §402.02). Interdependent actions have no independent utility apart from the proposed action (50 CFR §402.02) and depend on the project actions for justification. An example of a potential interrelated and interdependent action includes obtaining capping material from an off-site location that was developed specifically to supply capping material for the Portland Harbor remediation activities. (Note: this does not include material coming from an established gravel pit that is open and operating regardless of the proposed action.) At this time, this example is not expected to occur as a result of the proposed action, and no other interrelated/interdependent effects resulting from the proposed action have been identified.

Cumulative effects are effects of future state, tribal, local, or private actions that are reasonably certain to occur within the action area (50 CFR §402.02). From an ESA perspective, the analysis of cumulative effects considers future non-federal projects that do not require federal permits that may affect habitats and listed species in the action area. No such actions have been identified. Any future project involving in-water work within the action area will require a federal permit and appropriate ESA review. Future federal actions that are unrelated to this proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

5.4 DETERMINATION OF EFFECTS

The effects determination is the conclusion of the analysis of potential direct or indirect effects of the proposed activity together with the potential effects of other activities that are interrelated or interdependent with the proposed action on listed or proposed species and/or designated or proposed critical habitat. A formal biological opinion from the Services will make a determination of jeopardy/no jeopardy to the species at the population level and/or adverse modification/no adverse modification of designated critical habitat, and recommendations on reasonable and prudent measures, as appropriate. Regulatory guidance from the Final Section 7 Consultation Handbook (USFWS and NMFS 1998) was used to make the effects determination for the proposed activity as described below.

For listed species and designated critical habitat, the range of conclusions that could result from the effects analysis for the effects determination includes the following:

- No effect – the appropriate conclusion when the action agency determines its proposed action will not affect listed species or critical habitat.

- May affect, is not likely to adversely affect – the appropriate conclusion when effects on listed species are expected to be discountable, or insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. Based on best judgment, a person would not: 1) be able to meaningfully measure, detect, or evaluate insignificant effects; or 2) expect discountable effects to occur.

- May affect, is likely to adversely affect – the appropriate conclusion if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial (see definitions of "is not likely to adversely affect").

To distinguish between insignificant and significant effect on a listed species or critical habitat, one factor is whether or not the action is significant enough to result in a take. "Take," as defined by the ESA, includes such activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct [ESA §3(19)]. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering; harass is further defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, breeding, feeding or sheltering (50 CFR §17.3).

Sections 3 and 4 of this document defined the ESA-listed species and environmental baseline conditions in the action area, respectively. Sections 5.1 through 5.3 present the effects analysis based on potential direct and indirect impacts as well as interrelated, interdependent, and cumulative impacts of the proposed action on listed species and designated (and proposed in the case of Lower Columbia River coho salmon) critical habitat in the action area. This section provides specific effects determinations for each listed species and critical habitat based on the effects evaluation. **Table 5-4** provides the effects determinations for each species and critical habitat.

5.4.1 Effects Determinations for Salmonid Species in the Lower Willamette River

The effects determinations for salmonid species present in the Lower Willamette River is that this proposed action **may affect and is likely to adversely affect** Lower Columbia River Chinook salmon, Upper Willamette River Chinook salmon, Lower Columbia River steelhead, Upper Willamette River steelhead, and Lower Columbia River coho salmon. Justification for these determinations is provided below.

Although in-water work will occur during the in-water work window when listed fish are expected to either not be present or be present in very low numbers, it is possible that individual listed fish could be present in the action area. Implementation of avoidance and minimization measures would further reduce adverse effects; however, in-water work will occur with the risk that fish that are present could experience the following effects that are not discountable or insignificant:

- Water quality: short-term and localized impacts to water quality could result in resuspended contaminants in the water column, increased turbidity, and decreased DO during remedial activities, including dredging, capping, and in-situ treatment activities. Direct fish mortality or stress from suspended sediment is not expected to occur, any reduction in DO beyond background is expected to be localized and temporary in nature, and water quality effects are not expected to be at a level that would affect the abundance of water column prey items. Individual fish may be exposed to contaminant levels at concentrations greater than the acute criteria, particularly during dredging in areas with higher contamination concentrations.

- Substrate and forage: Substrate disturbance and disturbance of benthic and epibenthic prey items will occur during dredging, capping, and in-situ treatment activities. While this effect will be short-term and temporary due to expected rapid recovery of the benthic community, and the placement of beach mix, there may be long-term effects in areas where substrate is permanently altered with the use of riprap armoring.

- Shoreline Armoring and Slope: as described above, some armoring would occur in shoreline areas, and it may not be possible to restore ideal slope.

- Habitat Access and Refugia: There may be limited access to specific habitat areas from placement of construction barges and/or equipment during remediation work. However, this potential impact is expected to be short term and will not impact a majority of the fish that could be present in the proposed action area because the location of the construction equipment is only expected to cover a small percentage of the river width and would not substantially impact the movement of listed salmonid species. Long-term effects may occur in some areas, if dredging is required to a depth such that shallow water would be converted to deep water and/or there would be loss of shallow water habitat complexity provided by LWD, reducing the amount of shallow water habitat and refugia available.

- Natural Cover: while very limited in the action area, some riverbank areas may support natural riparian cover that would be removed or disturbed during remedial activities, and it may not be possible to restore natural cover in some areas.

- Entrainment: Entrainment in the dredge equipment during remediation is a potential direct impact to listed salmonid species. Additionally, there is some potential for entrainment during construction of a CDF, and fish capture techniques could lead to injuries to listed fish species.

5.4.2 Effects Determinations for Critical Habitat for Salmonid Species in the Lower Willamette River

The effects determinations for designated critical habitat for salmonid species in the Lower Willamette River is that the proposed action **may affect and is likely to adversely affect** designated critical habitat for Lower Columbia River Chinook salmon, Upper Willamette River Chinook salmon, Lower Columbia River steelhead, and Upper Willamette River steelhead. In addition, the proposed action would adversely modify proposed critical habitat for Lower Columbia River coho salmon. If Lower Columbia

River coho salmon critical habitat is designated prior to completion of the proposed action, a provisional effects determination for critical habitat is the following: The proposed action **may affect and is likely to adversely affect** Lower Columbia River coho salmon critical habitat.

The proposed action may affect and is likely to adversely affect critical habitat for these species because of the potential for long-term adverse effects to habitat characteristics important for freshwater rearing and migration PCEs, as follows:

- Natural Cover: While very limited in the action area, some riverbank areas may support natural riparian cover that would be removed or disturbed during remedial activities, and it may not be possible to restore natural cover in some areas.

- Substrate and Forage: Some areas of existing sand or gravel may be permanently lost with the placement of engineered caps that use riprap armor as a surface layer, and where placement of beach mix as a top layer is not possible.

- Shoreline Armoring and Slope: As described above, some armoring would occur in shoreline areas, and it may not be possible to restore ideal slope.

- Habitat Access and Refugia: In some areas, dredging may be required to a depth such that shallow water would be converted to deep water and/or there would be loss of shallow water habitat complexity, reducing the amount of shallow water habitat and refugia available.

- CDF: At the proposed T4 CDF location, approximately 14 acres of aquatic habitat would be converted to upland, resulting in permanent loss of aquatic habitat. Of the 14 total acres of aquatic habitat, approximately 3.3 acres, or about 24 percent of the total aquatic habitat, would be shallow water habitat (less than 20-feet deep).

5.4.3 Effects Determination for Species in the Lower Columbia River

The effects determinations for species likely to occur in the Lower Columbia River portion of the project area is that the proposed action **may affect but is not likely to adversely affect** Columbia River chum salmon, green sturgeon, or eulachon, or Columbia River bull trout.

The transport of dredged material in the federal navigation channel of the Lower Columbia River is not anticipated to result in adverse effects on Columbia River chum salmon, green sturgeon, or eulachon. Transport of sediments using sealed haul barges would avoid spills into the Lower Columbia River. Any spills or accidental releases of dredged material during offloading of contaminated sediments from barges at the transload facility will be avoided by implementing standard and appropriate material handling and containment procedures as described in Section 2.5.

Adverse effects on species that occur only in the Lower Columbia River portion of the action area could occur from construction of compensatory mitigation projects. Specifically, there would be short-term and localized increases in turbidity that could affect individual fish within work areas. However, the majority of this construction activity is expected to occur in upland areas that would be turned into shallow water areas as part of the mitigation action, and impact avoidance and minimization measures and BMPs described in Section 2.5 would be required during construction activities. Overall, compensatory mitigation projects are expected to result in long-term benefits to species in the Lower Columbia River from the conversion of existing upland habitat to shallow water habitat with sand/gravel substrates, shallow slopes, and shoreline complexity.

5.4.4 Effects Determinations for Critical Habitat for Species in the Lower Columbia River

The effects determinations for designated critical habitat in the Lower Columbia River is that the proposed action **may affect but is not likely to adversely affect** designated critical habitat for Columbia River chum salmon, green sturgeon, or eulachon. Proposed critical habitat for Lower Columbia River coho salmon is discussed in Section 5.4.2.

Designated critical habitat for Columbia River chum salmon, green sturgeon, and eulachon within the Lower Columbia River portion of the action area will not be impacted by the transport of dredged material in the federal navigation channel. Transport of sediments using sealed haul barges would avoid spills into the Lower Columbia River. Any spills or accidental releases of dredged material during offloading of contaminated sediments from barges at the transload facility will be avoided by implementing standard and appropriate material handling and containment procedures as described in Section 2.5.

The effects of the proposed mitigation construction on designated critical habitat in the Lower Columbia River would include short-term impacts on water quality, resulting from turbidity during the mitigation site construction, and long-term benefits to water connectivity, migratory habitat, shoreline complexity, and substrate. With implementation of avoidance and minimization measures and BMPs described in Section 2.5 during construction of compensatory mitigation projects, adverse impacts on designated critical habitat for Columbia River chum salmon, green sturgeon, or eulachon would not be anticipated.

5.4.5 Effects Determination for Southern Resident Killer Whale

The effects determination for killer whale present in the Lower Columbia River is that the proposed action **may affect but is not likely to adversely affect** killer whale because it is unlikely that their salmonid prey would be exposed to resuspended contaminants for the reasons provided in Section 5.2.4.

6.0 ESSENTIAL FISH HABITAT ASSESSMENT

This document also serves as a resource document for the concurrent EFH consultation with NMFS for compliance with the Magnuson-Stevens Act and the 1996 Sustainable Fisheries Act (SFA). EFH is defined by the Magnuson-Stevens Act in 50 CFR 600.905-930 as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

The objective of this EFH assessment is to determine whether or not the proposed action "may adversely affect" designated EFH for relevant commercial, federally managed fisheries species within the proposed action area. It also describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

The entire proposed action area includes habitats that have been designated as EFH for the Pacific salmon composite. EFH for the Pacific coast salmon fishery means those waters and substrate necessary for salmon production needed to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem (Pacific Fisheries Management Council [PFMC] 1999). Freshwater EFH for Pacific salmon includes those streams, lakes, ponds, wetlands, and other waterbodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable constructed barriers (as identified by PFMC) and longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for several hundred years; PFMC 1999). Adult and juvenile Chinook and coho salmon have designated EFH within the proposed action area. Juvenile and adult Chinook and coho salmon habitat and biological requirements are described in Section 3.

Freshwater EFH for Chinook and coho salmon consists of four major components (PFMC 1999):

- Spawning and incubation (not applicable to the proposed action area)
- Juvenile rearing
- Juvenile migration corridors
- Adult migration corridors and adult holding habitat (Chinook salmon only)

Important features of EFH for the four components listed above include adequate substrate composition; water quality such as appropriate DO, nutrients, and temperature; water quantity, depth, and velocity; channel gradient and stability; food; cover and habitat complexity, including items such as large woody debris, pools, channel complexity, and aquatic vegetation; space; access and passage; and floodplain and habitat connectivity (PFMC 1999).

6.1 PROPOSED ACTION

A detailed description of the proposed action and associated construction methods is provided in Section 2.

6.2 EFFECTS ANALYSIS

This section discusses the potential adverse effects of the proposed action on the applicable EFH within the proposed action area. The specific elements of the proposed action that could impact salmonid species' EFH include substrate disturbance or modification, water quality changes, and in-water work activities. The impact mechanisms and conservation measures to avoid and minimize impacts are identified in **Table 6-1** and summarized below.

- Natural Cover - while very limited in the action area, some riverbank areas that support natural riparian cover may be removed or disturbed during remedial activities, and it may not be possible to restore natural cover in some areas.

- Substrate and Forage - some areas of existing sand or gravel may be permanently lost with the placement of engineered caps that use riprap armor as a surface layer and where placement of beach mix as a top layer is not possible. However, re-deposition of fine-grained material in armored areas is anticipated to occur over time, making the armored areas similar in surface grain size to non-armored areas.

- Shoreline Armoring and Slope - as described above, some armoring would occur in shoreline areas, and it may not be possible to restore ideal slopes.

- Habitat Access and Refugia - in some areas, dredging may be required such that shallow water would be converted to deep water and/or there would be loss of shallow water habitat complexity provided by LWD, thus reducing the amount of shallow water habitat and refugia available.

- CDF - at the proposed T4 CDF location, approximately 14 acres of aquatic habitat would be converted to upland, resulting in permanent loss of aquatic habitat. Of the 14 total acres of aquatic habitat, approximately 3.3 acres, or about 24 percent of the total aquatic habitat, would be shallow water habitat (less than 20 feet deep).

6.3 EFFECT DETERMINATION

Based on the potential impacts of the proposed action on salmonid EFH and appropriate impact minimization measures, conservation measures, and BMPs that are shown in **Table 6-1**, it is concluded that the effects of the proposed action **may adversely affect** Pacific Salmon EFH. A **may adversely affect** determination is appropriate because there will be short-term impacts on freshwater rearing sites and migration corridors as described in **Table 6-1**. However, long-term beneficial effects on EFH are also expected as a result of the proposed action based on the significant reduction and/or removal of sediment contamination from the Site.

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Table 1-1. Listed Species Evaluated in the Programmatic BA

NMFS Species	Status	Critical Habitat Status	Presence in the Action Area
Chinook salmon (*Oncorhynchus tshawytscha*)			
Upper Willamette River ESU	Threatened	Designated	LCR, LWR
Lower Columbia River ESU	Threatened	Designated	LCR, LWR
Upper Columbia River spring ESU	Endangered	Designated	LCR
Snake River spring/summer ESU	Threatened	Designated	LCR
Snake River fall ESU	Threatened	Designated	LCR
Chum salmon (*Oncorhynchus keta*), Columbia River ESU	Threatened	Designated	LCR
Coho salmon (*Oncorhynchus kisutch),* Lower Columbia River ESU	Threatened	Proposed	LCR, LWR
Sockeye salmon *(Oncorhynchus nerka),* Snake River Basin ESU	Endangered	Designated	LCR
Steelhead trout *(Oncorhynchus mykiss)*			
Upper Willamette River DPS	Threatened	Designated	LCR, LWR
Lower Columbia River DPS	Threatened	Designated	LCR, LWR
Upper Columbia River DPS	Endangered	Designated	LCR
Middle Columbia River DPS	Threatened	Designated	LCR
Snake River Basin DPS	Threatened	Designated	LCR
Eulachon (*Thaelichthys pacificus),* Southern DPS	Threatened	Designated	LCR
Green sturgeon (*Acipenser medirostris),* Southern DPS	Threatened	Designated	LCR
Killer Whale (*Orcinus orca*), Southern Resident DPS	Endangered	Designated, not within action area	LCR[1]
USFWS Species			
Bull trout *(Salvelinus confluentus)*	Threatened	Designated	LCR

Key:

NMFS = National Marine Fisheries Service

USFWS = U.S. Fish and Wildlife Service

ESU = Evolutionarily Significant Unit

DPS = Distinct Population Segment

LCR = Lower Columbia River

LWR = Lower Willamette River

Notes:

[1]Species does not occur in the LWR, but is included for potential effects to salmonid prey in the LCR.

Table 2-1. Acres Assigned to Each Technology Type

Capping									
Intermediate Areas						Shallow Areas			
Aquablok	Armored	Engineerd Cap	Reactive Cap	Reactive Armored Cap	Signifcantly Augmeted Reactive Cap	Aquablok	Armored	Reactive Armored Cap	Signifcantly Augmeted Reactive Cap
(acres)						(acres)			
5.16	10.67	1.69	9.64	34.08	1.07	0.98	0.10	0.59	0.14

Dredging											
NAV		FMD		Intermediate Areas			Shallow Areas				
Residual Layer	Reactive Residual Layer	Residual Layer	Reactive Residual Layer	Residual Layer	Reactive Residual Layer	Significantly Augmented Reactive Cap	Backfill	Reactive Residual Layer	Engineered Cap	Reactive Cap	Significantly Augmented Reactive Cap
(acres)		(acres)		(acres)			(acres)				
28.54	10.92	62.16	11.39	3.14	9.46	0.36	10.91	13.72	2.99	13.36	0.16

In-Situ Treatment	EMNR	MNR	Previously Remediated	Total Site Acres
Broadcast AC	Residual Layer	Dispersion or Deposition		
(acres)	(acres)	(acres)	(acres)	(acres)
0.03	60	1,876	23	2,190

Notes:

EMNR -Enhanced Monitored Natural Recovery

FMD - Future Maintenance Dredge Area

MNR - Monitored Natural Recovery

NRC - Not reliably contained

PTW - Principal Threat Waste

Table 2-2. Summary of Dredge Volumes and Material Quantities

Total Dredge Volume[1]		Ex-Situ Treatment		Material Volumes for Containment, Dredge Residuals Management, and In-Situ Treatment[2]						
Low Estimate	High Estimate	Low Estimate	High Estimate	Sand	Low-Permeability Sand	Organoclay Mats	Beach Mix	Armor	Aquablok	AquaGate + 10% PAC
(cy)		(cy)		(cy)					(tons)	
1,419,000	1,892,000	169,000	225,000	595,000	3,900	230	34,000	78,700	5,700	80,800

Notes:

1) Estimated range of volume for alternatives derived by multiplying the "neat" dredge volume by 1.5 for the low range and by 2 for the high range.

2) All material quantities expressed as in-situ, neat measurements.

Table 2-3. Summary of Excavated Riverbank Volumes and Material Quantities

Technology Name	Length of Riverbank (FT)	Surface Area (AC)
Dredge with engineered cap (3ft)	17,678	19.25
Dredge with significantly augmented reactive cap (3ft), with armoring	1,794	1.95
Monitored Natural Recovery	10,577	11.5
Total	30,048	32.7

Table 2-4. Years to Complete Construction

Dredging				Capping		Organoclay Mat		Total	
(low days)	(high days)	(low work years)	(high work years)	(days)	(work years)	(days)	(work years)	(low work years)	(high work years)
277	370	2.27	3.03	202	1.65	0.4	0.00	**3.93**	**4.69**

currently in QC review

Inputs and assumptions for construction duration calculations

122	days per year in-water work window	1. In-water work window is 122 days per year
5100	total cubic yards dredged per day	2. Estimated dredge durations are based on an assumed 6,000 CY/day dredged and the estimated range of dredged volumes, but with production rate revised to 6,000*6/7 = 5,100 cy/day as a weekly average.
		2a. Daily dredge production rates were developed assuming a 55/45% mix of cable arm versus articulated bucket dredges, based on the approximate areal percentages of navigation channel and maintenance dredge areas in the alternatives. Dredging and excavation operations are assumed to occur 24 hours/6 days per week using three dredges. The daily and weekly durations of removal operations may be refined if community “quality of life” concerns (such as nighttime noise or light pollution) are identified. However, for this FS, it is assumed that 24 hour per day dredging activities can be achieved given the industrial nature of the majority of the surrounding areas.
---	---	The planning-level productivity estimate for a cable arm dredge was developed based on operational characteristics for environmental dredging and guidance presented in USACE (2008). The production rate is the product of the bucket volume (10 cy), cycle time (2 min), and percent bucket fill (60 percent), adjusted for effective working time (62.5%). Based on this analysis, the cable arm dredge productivity rate is approximately 2,700 cy/day/dredge plant. The productivity estimates of the articulated bucket dredge are derived from recent site experience at Boeing Plant 2 removal at the Duwamish River Superfund Site. There, the daily production rate during the latest season of dredging was approximately 1,150 cy/day using a single 4-cy excavator-mounted bucket. Assuming the above number and mix of these dredge types, 6,000 cy/day was estimated for daily production.............[(55% * 2,700 cy/day) + (45% * 1,150 cy/day)] * 3 dredge plants = 6,000 cy/day
---	---	3. Dredge duration calculated on a volumetric, not areal, basis. Debris fields, piling removal, etc. are not explicitly incorporated into duration assumptions.
3900	total cubic yards placed per day	4. Cap/EMNR placement rate assumes 1,500 CY of material placed per day per placement plant. Construction duration calculations assume 3 plants operating 6 days per week with 1 day of maintenance per week for the 122 day in-water work window. (3 plants*1,500 CY/day) = 4,500 CY/day placed, but with placement rate revised to 4,500*6/7 = 3,900 CY/day as a weekly average.
---	---	5. Cap and EMNR construction is assumed to occur in sequence (not in parallel) with dredging for estimating total construction duration
---	---	6. Ex-situ treatment volumes are assumed to be a subset of the dredged material volumes.
---	---	7. Construction duration calculations assume that the total dredge and placement material volumes presented above are accurate.
1	thickness of capping materials in yards	8. Caps are assumed to be three feet in thickness.
1.15	AquaBlok/AquaGate tons per cubic yard	9. AquaBlok and AquaGate+PAC 10% are both assumed to have an average dry bulk density of 85lb/CF.
4	acres of organoclay mat placed per day	10. Organoclay mat placement rate can vary significantly and is best estimated following an inspection of the placement area by the placement contractor. It is the expectation of an organoclay mat vendor that placement rates will increase as the project progresses for larger quantities of mats. The vendor further expects the placement rate to vary between 1-10 acres/day, and recommends 4 acres/day for these FS estimates. Organoclay mat placement is assumed to be conducted in sequence (not in parallel) with capping and dredging operations for estimating total construction duration.
0.01	acres covered by 1 cubic yard of material incorporated into a 1-inch thick mat	11. Organoclay mats are assumed to be applied in a 1-inch thick mat.

Table 5-1. Summary of Effects on Listed Species

		Exposure							
Action	Where	Stressor	When	Duration	Frequency	Life History Form	Response to Stressor	Avoidance and Minimization Measures	Resulting Effects of the Action
Dredging, Capping, and In-Situ Treatment Activities, and construction of CDF berm	Lower Willamette River	a) Water quality (exposure to contaminants, turbidity, decreased DO)	Short-term during construction activities	4 month in-water work window (July 1 – October 31); 4-5 years of construction	During work hours, which for dredging could be 24 hours/day for 6 days/week	Primarily juvenile Chinook ESUs	Physiological, behavioral, mortality	In-water work window, BMPs, operational and engineering controls of suspended sediment, water quality monitoring	Measures will avoid and minimize to the extent possible
		b) Reduction in natural cover	During construction; permanent loss in some areas				Behavioral, loss of habitat	Restore riparian cover where possible	Some permanent loss to be offset by compensatory mitigation
		c) Reduction in substrate and forage	During construction; permanent loss in some areas	Long-term (1 year), until benthic community recovers. Duration of construction is 4-5 years.			Behavioral, loss of habitat	Restore substrate with beach mix (shallow) and sand residual cover	Some permanent loss to be offset by compensatory mitigation
		d) Increase in shoreline armoring and slope	During construction; permanent loss in some areas				Behavioral, loss of habitat	Restore slope where possible	Some permanent loss to be offset by compensatory mitigation
		e) Reduction in habitat access and refugia	During construction; permanent loss in some areas				Behavioral, loss of habitat	Restore substrate and slope	Some permanent loss to be offset by compensatory mitigation
		f) Entrainment	Short-term during construction activities	4 month in-water work window (July 1 – October 31); 4-5 years of construction	During work hours, which for dredging could be 24 hours/day for 6 days/week		Mortality, harm	In-water work window, BMPs, operational and engineering controls	Measures will avoid and minimize to the extent possible
		g) Noise	Short-term during construction activities	4 month in-water work window (July 1 – October 31); 4-5 years of construction	During work hours, which for dredging could be 24 hours/day for 6 days/week		Behavioral		
Long-term Monitoring		Entrainment	Short-term during construction activities				Mortality, harm		
Construction of compensatory mitigation projects	Lower Columbia River	Water quality (turbidity, decreased DO)	Short-term during construction activities	4 month in-water work window (July 1 – October 31); 4-5 years of construction	During work hours, which for dredging could be 24 hours/day for 6 days/week	Adults and juveniles of Columbia River species (salmonids, green sturgeon, eulachon)	Physiological, behavioral, mortality	In-water work window, BMPs, operational and engineering controls	Measures will avoid and minimize to the extent possible
		Entrainment	Short-term during construction activities	In-water work window (November 1 through February 28)	During work hours for individual mitigation projects		Mortality, harm		

Table 5-2. Summary of Effects on Salmonid Critical Habitat PCEs

Primary Constituent Element		Environmental Baseline		Dredging		Capping, In-Situ Treatment, EMNR		Construction and Operation of CDF		Removal and Installation of Piling		Construction of Compensatory		MNR		Upland Disposal	
Type	**Characteristic**	**Not Properly Functioning**	**Properly Functioning**	**Maintain**	**Degrade**	**Maintain**	**Degrade**	**Maintain**	**Degrade**	**Maintain**	**Degrade**	**Maintain**	**Degrade**	**Maintain**	**Degrade**	**Maintain**	**Degrade**
Freshwater Rearing	Water Quality	x			Short-term		Short-term		Short-term		Short-term		Short-term	x		x	
Freshwater Rearing	Water Quantity	x		x		x		x		x		x		x		x	
Freshwater Rearing	Floodplain Connectivity	x		x		x		x		x		Benefit		x		x	
Freshwater Rearing	Natural Cover	Depends on location within the Site			Short-term and Potential Long- term		Short-term and Potential Long- term		Long-term loss	x		Benefit		x		x	
Freshwater Rearing	Forage	Depends on location within the Site			Short-term and Potential Long- term		Short-term and Potential Long- term		Long-term loss	x		Benefit				x	
Freshwater Migration	Water Quality	x			Short-term		Short-term		Short-term		Short-term		Short-term	x		x	
Freshwater Migration	Water Quantity	x		x		x		x		x		x		x		x	
Freshwater Migration	Natural Cover	Depends on location within the Site			Short-term and Potential Long- term		Short-term and Potential Long- term		Long-term loss	x		Benefit		x		x	
Freshwater Migration	Artificial Obstructions		x	x		x		x		x		x		x		x	

Table 5-3. Habitat Equivalency Analysis Scoring (Portland Harbor Natural Resource Trustee Council, 2010)

Habitat	Habitat Characteristics	Salmonid Value
Riparian	Naturally vegetated forest, <400 feet from ACM [1]	0.5
	and in the historic floodplain	0.65
	Naturally vegetated grass/shrub	0.2
	and associated with historic floodplain	0.35
	Invasive species[2]	0.1
	Unvegetated riprap	0.05
	Unvegetated/paved/buildings/riprap	0
Active Channel Margin	Sloped (< 5:1 or 11 degrees), unarmored and vegetated[3]	1
	Sloped (> 5:1 or 11 degrees), unarmored and vegetated[3]	0.8
	Sloped (< 5:1 or 11 degrees), unarmored and unvegetated	0.8
	Sloped (> 5:1 or 11 degrees), unarmored and unvegetated	0.1
	Sloped (< 5:1), bio-engineered	0.2
	Sloped (> 5:1), bio-engineered	0.2
	Riprapped	0
	Sheetpile	0
	Pilings	1/2 value of margin type
	Covered structures over channel margins[4]	0.1
Main channel	Shallow water, gravel and finer substrates	1 (0.9)
	Shallow water, natural rock outcrop[5]	1 (0.9)
	Shallow water with riprap or concrete	0.1 (0.1)
	Shallow water with covering structures	0.1 (0.1)
	Shallow water with pilings	1/2 value of channel type
	Deep water with natural substrates	0.1
	Deep water with artificial substrates	0.05
Off-channel	"Cold" water tributary	1
	"Warm" water tributary	0.9
	Side channel	1
	Alcove or slough with tributary	1 [6]
	Alcove or slough without tributary	0.8
	Embayment (cove) with tributary	1 [6]
	Embayment (cove) without tributary	0.8 [7]

Notes

[1]ACM = active channel margin

[2]e.g., Himalayan blackberry

[3]native species, value is 1/2 the value listed if vegetated with invasive species

[4]e.g., docks

[5]cannot be created

[6]value is 0.9 for salmonid adults if "warm" water tributary

[7]value is around 0.6 further upstream

Table 5-4. Effects Determinations

NMFS Species	Effects Determination for Species	Effects Determination for Critical Habitat
Chinook salmon (*Oncorhynchus tshawytscha*)		
Upper Willamette River ESU	**LTAA**	**LTAA**
Lower Columbia River ESU	**LTAA**	**LTAA**
Upper Columbia River spring ESU	NLTAA	NLTAA
Snake River spring/summer ESU	NLTAA	NLTAA
Snake River fall ESU	NLTAA	NLTAA
Chum salmon (*Oncorhynchus keta*), Columbia River ESU	NLTAA	NLTAA
Coho salmon (*Oncorhynchus kisutch),* Lower Columbia River ESU	**LTAA**	**would adversely modify; LTAA (if designated)**
Sockeye salmon *(Oncorhynchus nerka),* Snake River Basin ESU	NLTAA	NLTAA
Steelhead trout *(Oncorhynchus mykiss)*		
Upper Willamette River DPS	**LTAA**	**LTAA**
Lower Columbia River DPS	**LTAA**	**LTAA**
Upper Columbia River DPS	NLTAA	NLTAA
Middle Columbia River DPS	NLTAA	NLTAA
Snake River Basin DPS	NLTAA	NLTAA
Eulachon (*Thaelichthys pacificus),* Southern DPS	NLTAA	NLTAA
Green sturgeon (*Acipenser medirostris),* Southern DPS	NLTAA	NLTAA
Killer Whale (*Orcinus orca*), Southern Resident DPS	NLTAA	NA
USFWS Species		
Bull trout *(Salvelinus confluentus)*	NLTAA	NLTAA

Key:

DPS = Distinct Population Segment

ESU = Evolutionarily Significant Unit

LCR = Lower Columbia River

LTAA = likely to adversely affect

LWR = Lower Willamette River

NA = not applicable (designated critical habitat does not occur in action area)

NLTAA = not likely to adversely affect

NMFS = National Marine Fisheries Service

USFWS = U.S. Fish and Wildlife Service

Notes:

[1]Species does not occur in the LWR, but is included for potential effects to salmonid prey in the LCR.

Table 6-1. Summary of Effects on EFH	
Affected EFH	**Impact Discussion**
Water quality will be adversely affected.	Short-term and localized impacts to water quality could result in resuspended contaminants in the water column, increased turbidity, and decreased DO during remedial activities, including dredging, capping, and in-situ treatment activities. Direct fish mortality or stress from suspended sediment is not expected to occur, any reduction in DO beyond background is expected to be localized and temporary in nature, and water quality effects are not expected to be at a level that would affect the abundance of water column prey items. Individual fish may be exposed to contaminant levels at concentrations greater than the acute criteria, particularly during dredging in areas with higher contamination concentrations.
Shoreline habitat used by salmonids will be affected within the Site.	Short-term: There may be limited access to specific habitat areas from placement of construction barges and/or equipment during remediation work. However, this potential impact is expected to be short term and will not impact a majority of the fish that could be present in the proposed action area because the location of the construction equipment is only expected to cover a small percentage of the river width and would not substantially impact the movement of listed salmonid species.
	Long-term: Some armoring would occur in shoreline areas, and it may not be possible to restore ideal slope. Long-term effects may also occur in some areas, if dredging is required to a depth such that shallow water would be converted to deep water and/or there would be loss of shallow water habitat complexity provided by LWD, reducing the amount of shallow water habitat and refugia available. While very limited in the action area, some riverbank areas may support natural riparian cover that would be removed or disturbed during remedial activities, and it may not be possible to restore natural cover in some areas.
Benthic habitat will be disturbed.	Short-term impacts relate to the removal or covering of existing benthic communities which will not provide forage opportunities until the community can be re-established.
	Long-term impacts relate to the conversion of aquatic areas to upland from construction of a CDF for dredged material placement. In addition, there may be long-term effects in areas where substrate is permanently altered with the use of riprap armoring.
Permanent loss of aquatic habitat will occur.	At the proposed T4 CDF location, approximately 14 acres of aquatic habitat would be converted to upland, resulting in permanent loss of aquatic habitat. Of the 14 total acres of aquatic habitat, approximately 3.3 acres, or about 24 percent of the total aquatic habitat, would be shallow water habitat (less than 20-feet deep).

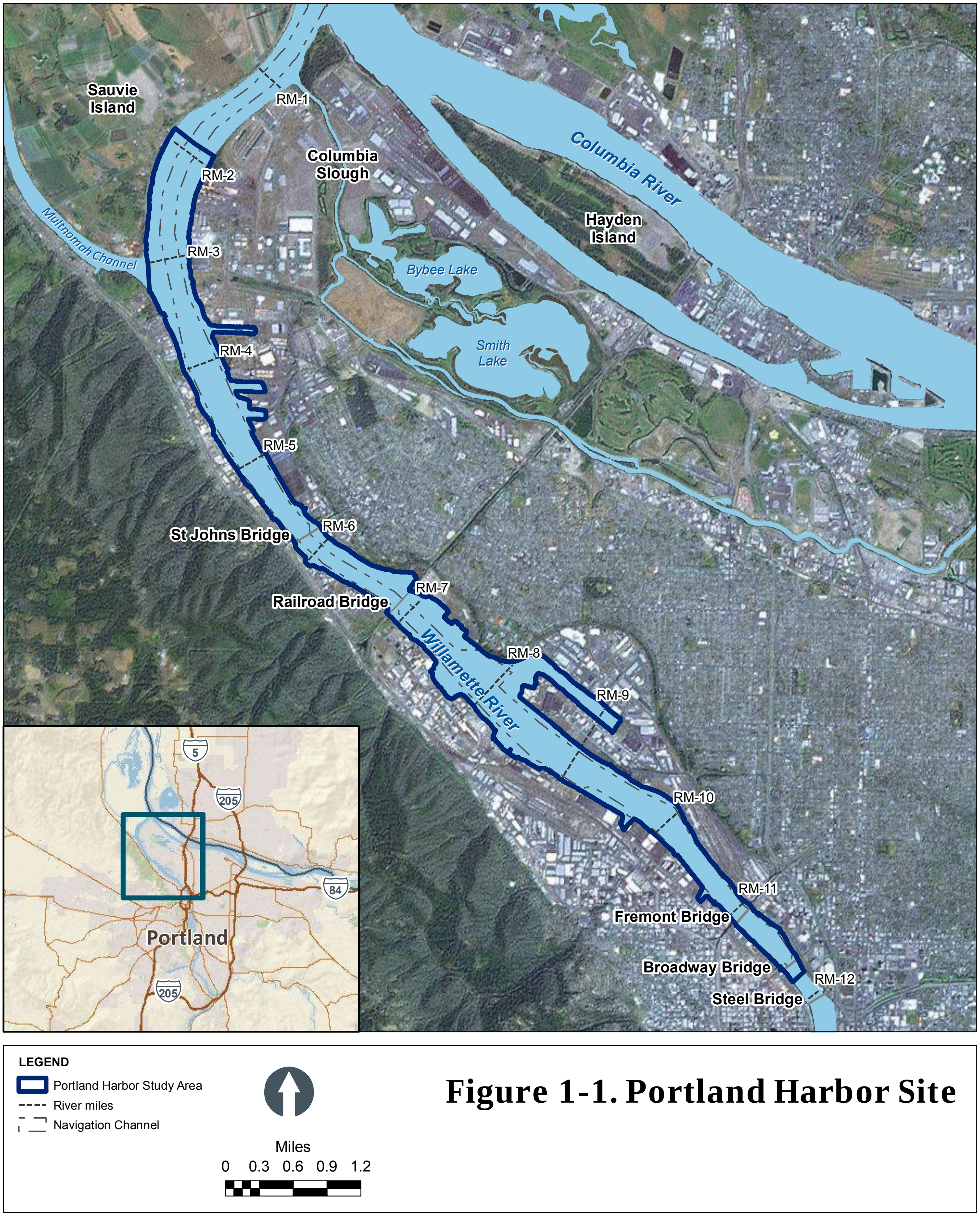
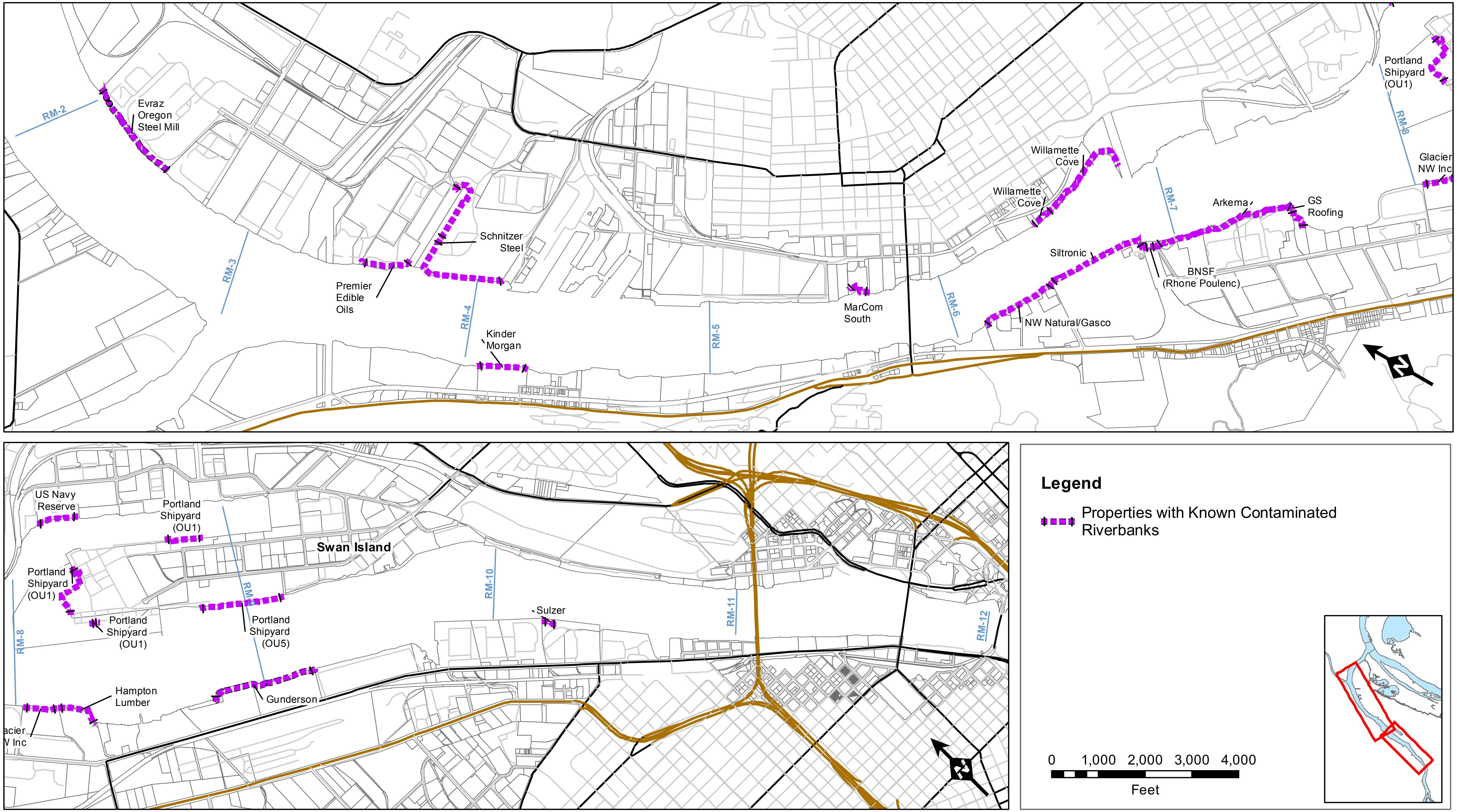


Figure 1-1. Portland Harbor Site



Source Credits:

Figure 1-2. Riverbank Areas

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Date: 2/29/2016

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 1-2b.
Riverbank Areas
Rivermile 1.9 to 4

0 500 1,000
Feet

Date Saved: 3/1/2016 12:26:37 PM

Note: Technology assignments are conceptual for FS evaluation purposes and assignments will be refined during remedial design.

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 1-2c.
Riverbank Areas
Rivermile 4 to 6

0 500 1,000
Feet

Date Saved: 3/1/2016 12:26:37 PM

Note: Technology assignments are conceptual for FS evaluation purposes and assignments will be refined during remedial design.

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 1-2d.
Riverbank Areas
Rivermile 6 to 8

0 500 1,000
Feet

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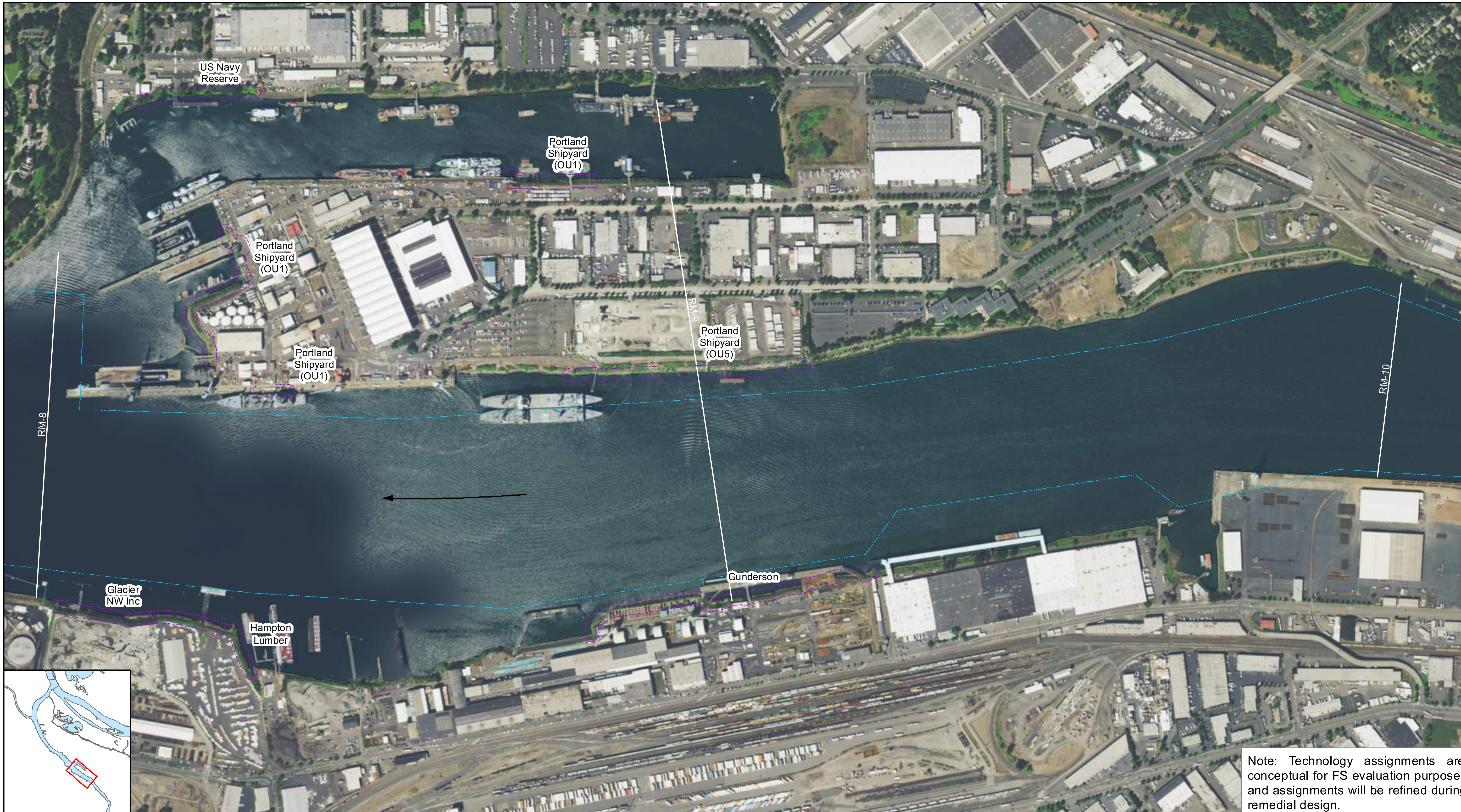

Note: Technology assignments are conceptual for FS evaluation purposes and assignments will be refined during remedial design.

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 1-2e.
Riverbank Areas
Rivermile 8 to 10

0 500 1,000
Feet

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 1-2f.
Riverbank Areas
Rivermile 10 to 12

0 500 1,000
Feet

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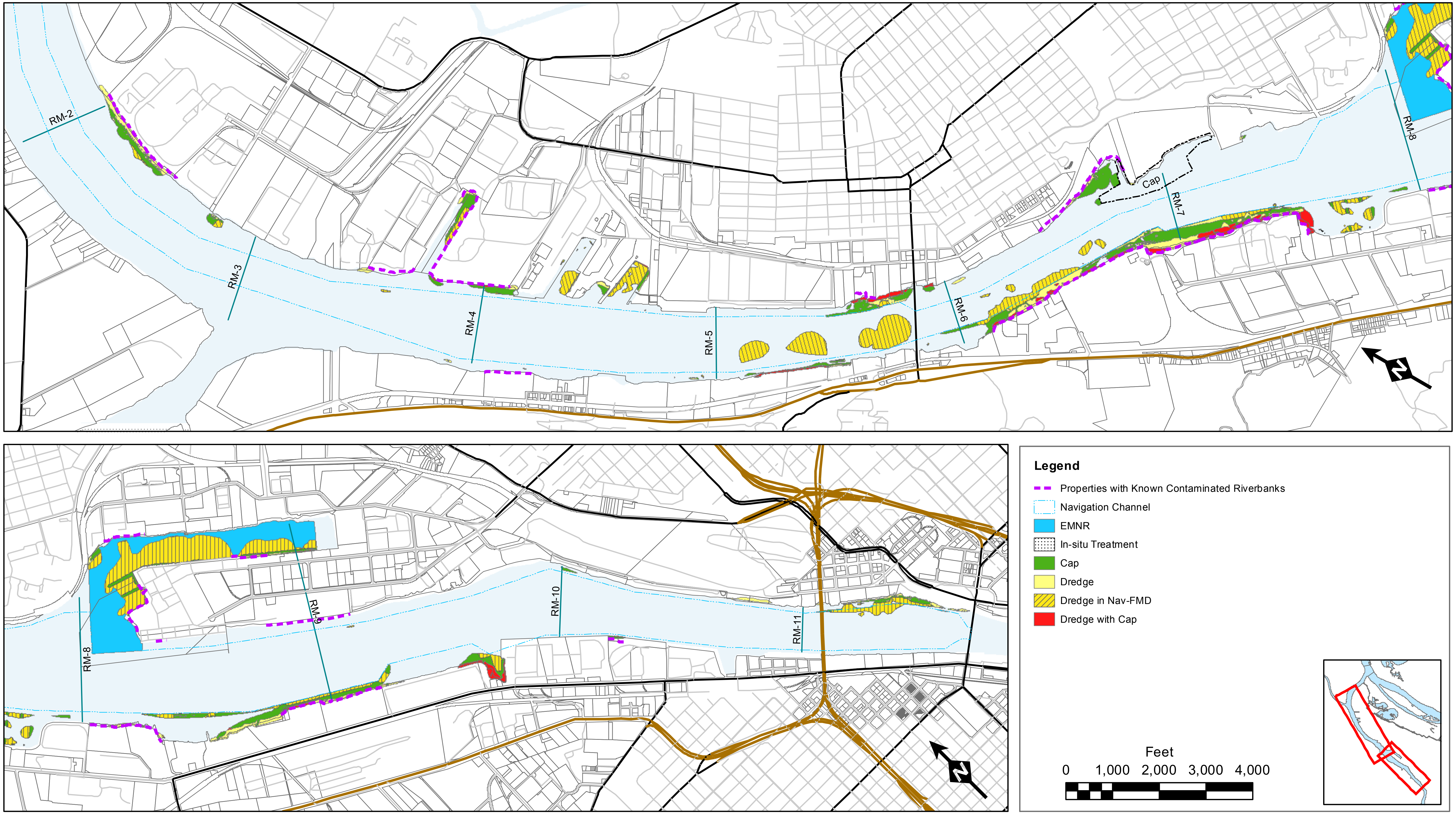

Figure 2-1a. Footprint of Remediation for Proposed Action, Site-wide

Path: E:_Projects\Portland Harbor\GIS\MapDocuments\Biological Assessment\Figure2-1a_Tech-Assign-Site-wide-AltH.mxd, Created by: MLF

Date: 2/29/2016

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 2-1b.
Footprint of Remediation for Proposed Action
Rivermile 1.9 to 4

0 500 1,000
Feet

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Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

- Properties with Known Contaminated Riverbanks
- River Flow
- Navigation Channel
- EMNR
- In-situ Treatment
- Cap
- Dredge
- Dredge in Nav-FMD
- Dredge with Cap

Figure 2-1c.
Footprint of Remediation for Proposed Action
Rivermile 4 to 6

N

0 500 1,000
Feet

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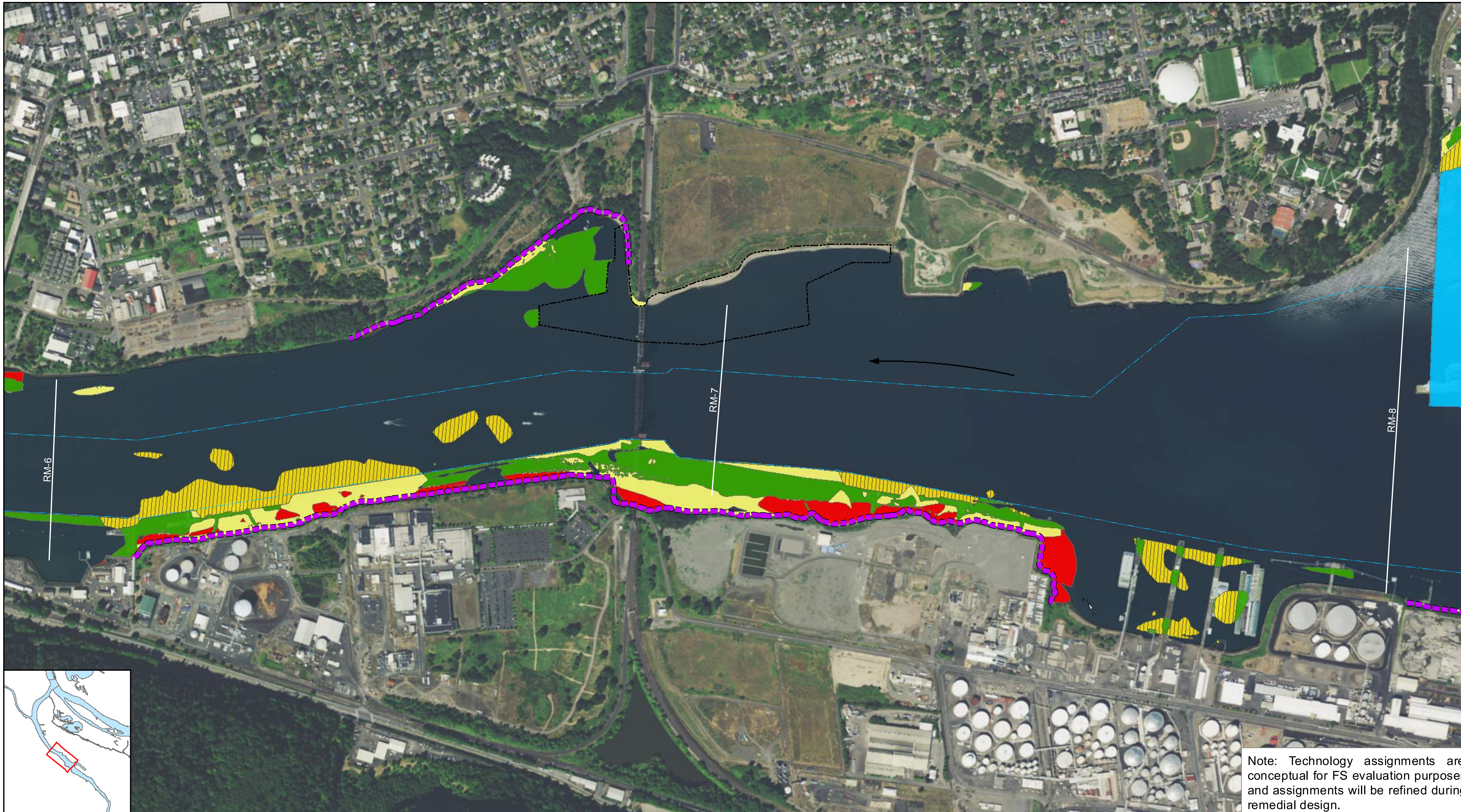

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 2-1d.
Footprint of Remediation for Proposed Action
Rivermile 6 to 8

0 500 1,000
Feet

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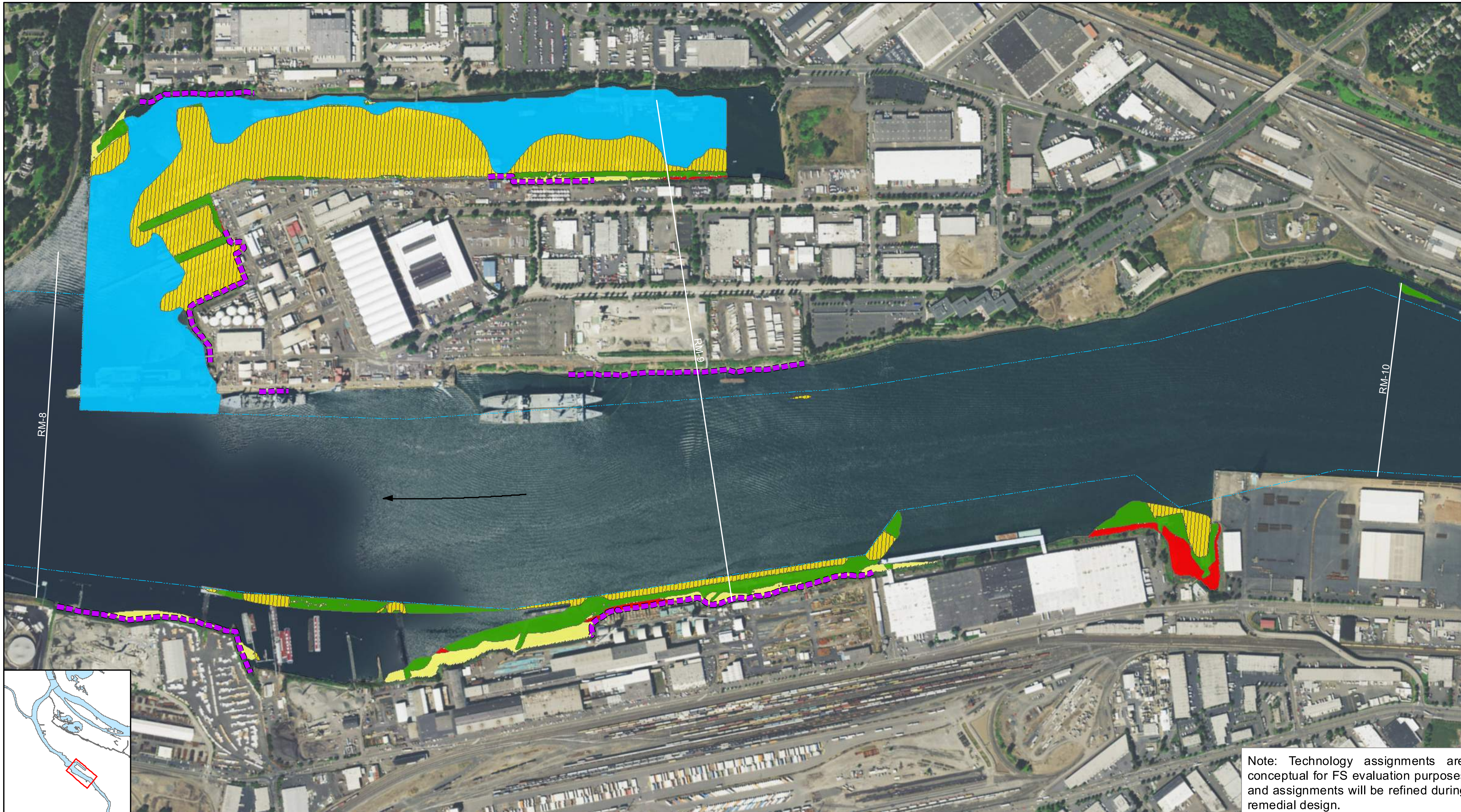

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Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 2-1e.
Footprint of Remediation for Proposed Action
Rivermile 8 to 10

0 500 1,000
Feet

Date Saved: 2/29/2016 11:19:00 AM

Source Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Properties with Known Contaminated Riverbanks
River Flow
Navigation Channel
EMNR
In-situ Treatment
Cap
Dredge
Dredge in Nav-FMD
Dredge with Cap

Figure 2-1f.
Footprint of Remediation for Proposed Action
Rivermile 10 to 12

N

0 500 1,000
Feet

Date Saved: 2/29/2016 11:19:00 AM

Figure 2-2. Potential Upland Disposal Facilities

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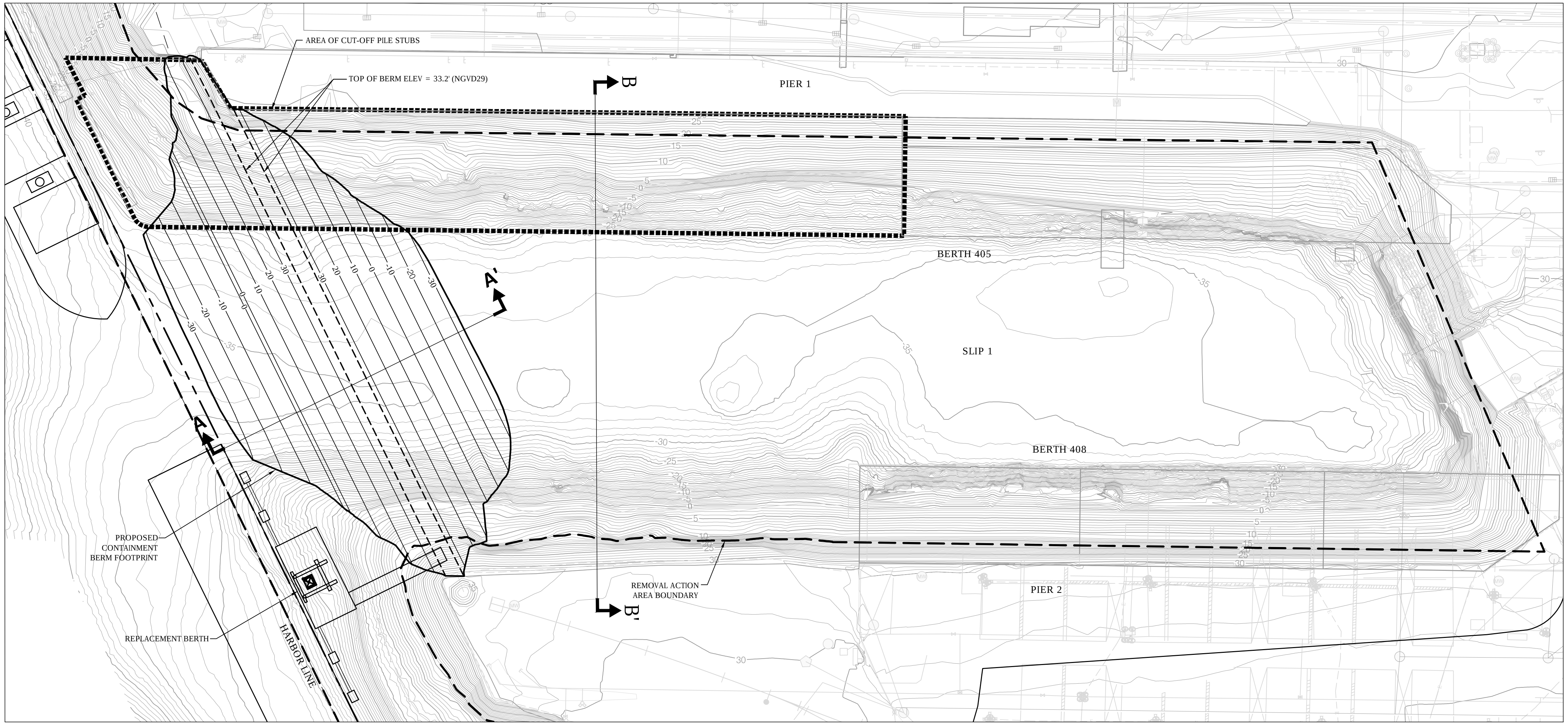
Figure 2-3. Location of Proposed Confined Disposal Facility



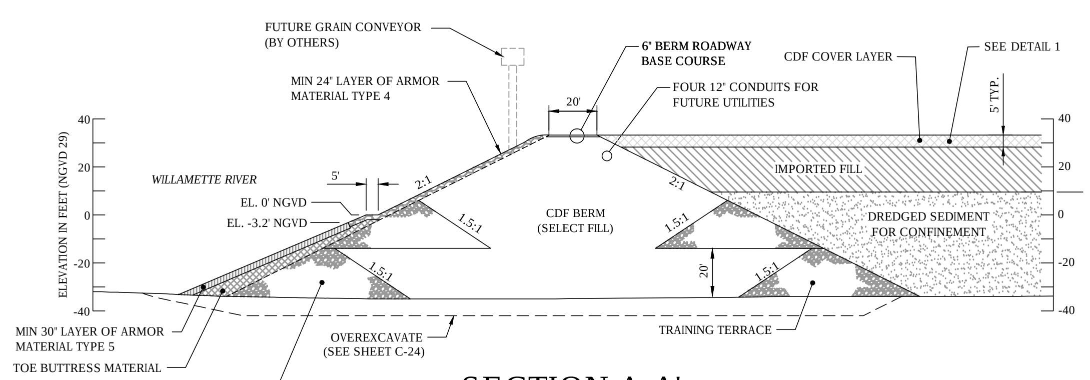
NOTES:

1. NGVD29 - National Geodetic Vertical Datum of 1929
   NAVD88 - North American Vertical Datum of 1988

2. HORIZONTAL DATUM: PORT OF PORTLAND
   LOCAL PROJECTION (INTERNATIONAL FEET)
   VERTICAL DATUM: NGVD 29-47
   CONTOUR INTERVAL = 1 FT

нɸ !¢ ¢I[{ [h/ !¢[hbΣ ¢I9 /hb±9w{[hb Cwh a bD±5нɸ ¢h b!±5yy[{ oɸπ C99¢ɸ ¢I9w9Chw9Σ ¢I9 9[9±!¢[hb OF THE TOP OF THE CAP IS +33.2 FEET NGVD29 (+36.6 FEET NAVD88) AND THE MAXIMUM ELEVATION FOR THE PLACEMENT OF DREDGED SEDIMENT FOR CONFINEMENT IS +9.5 FEET NGVD29 (+12.9 FEET NAVD88).

0 160
Scale in Feet

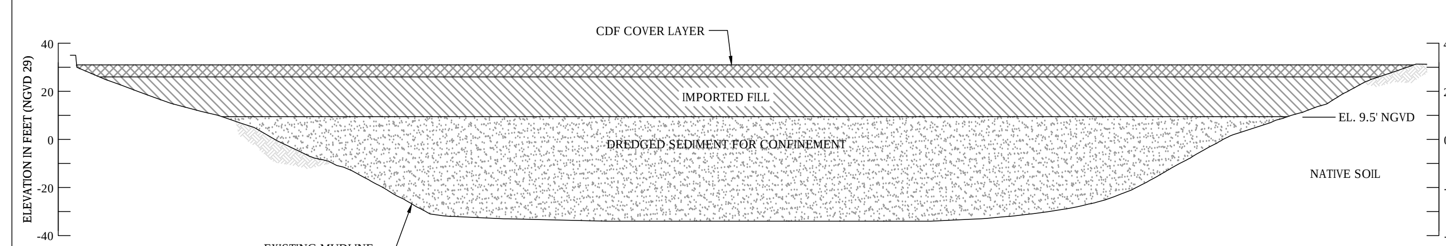


SECTION A-A'

0 80
Scale in Feet

NOTE:

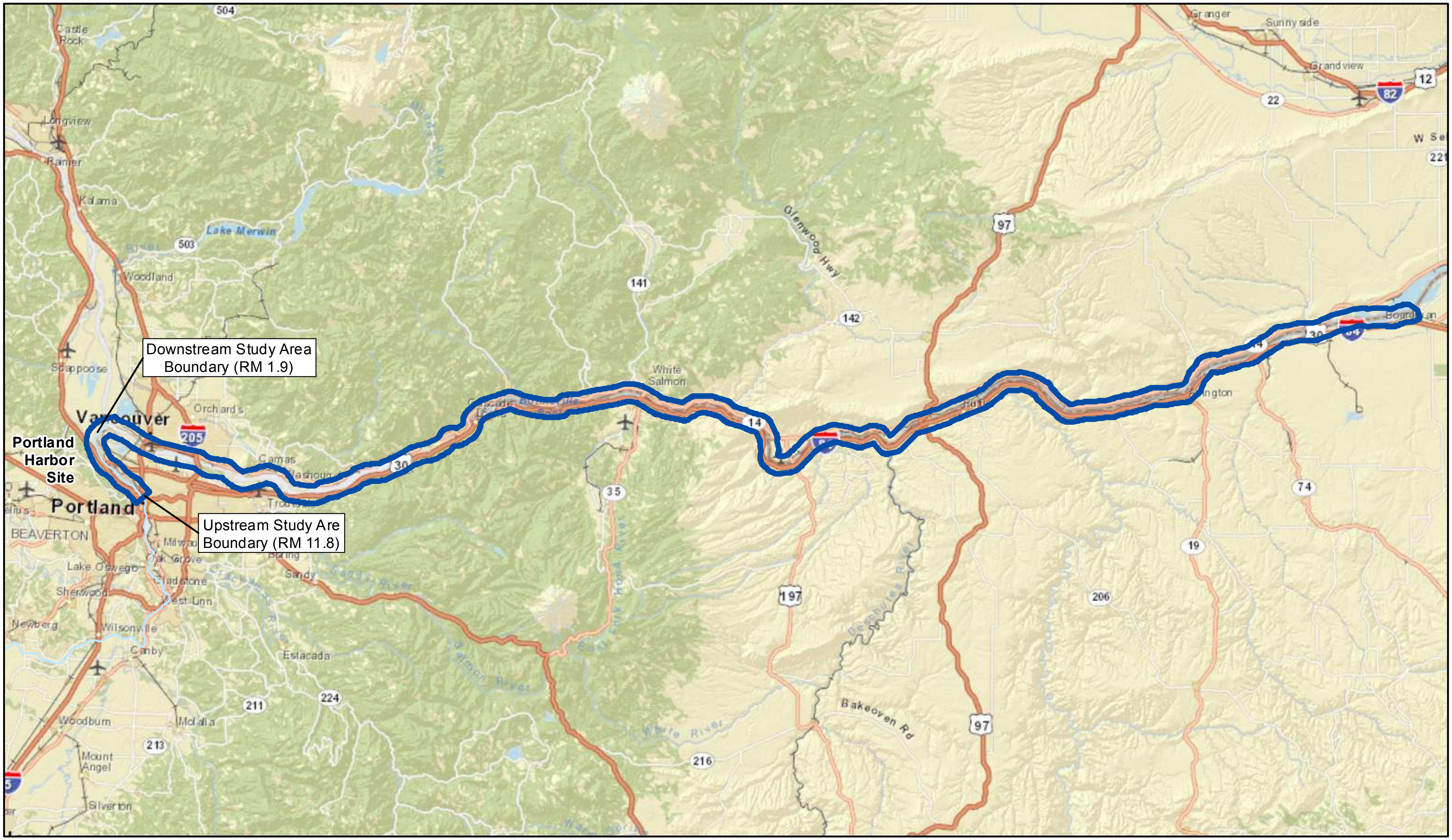
CONTRACTOR CAN USE TRAINING TERRACES TO BUILD THE BERM. THE TERRACES SHALL EACH BE 20' IN HEIGHT. SEE SPECIFICATIONS FOR MORE DETAILS.



SECTION B-B'

0 80
Scale in Feet

Figure 2-4. CDF Concept Plan View

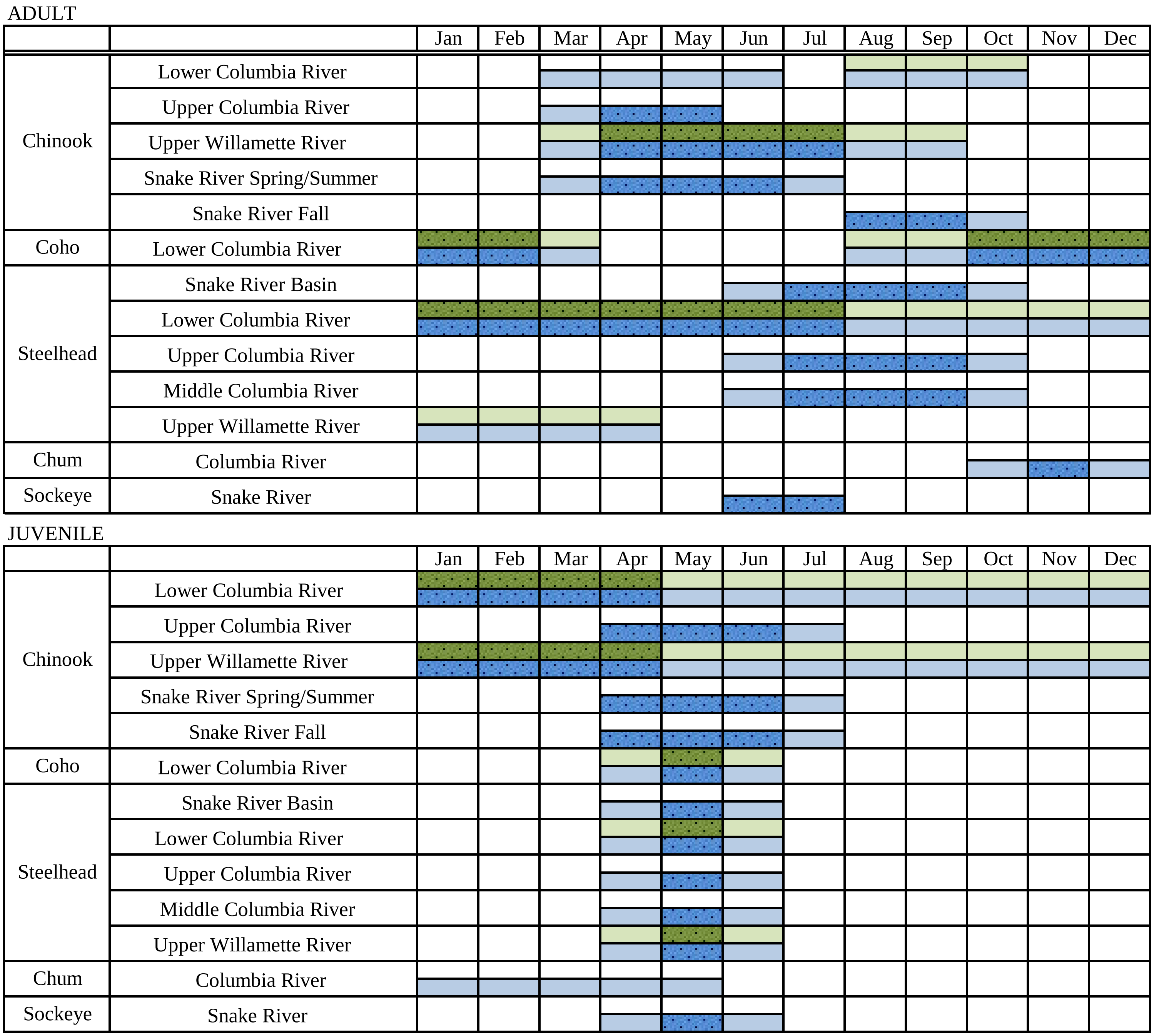


Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Proposed Action Area

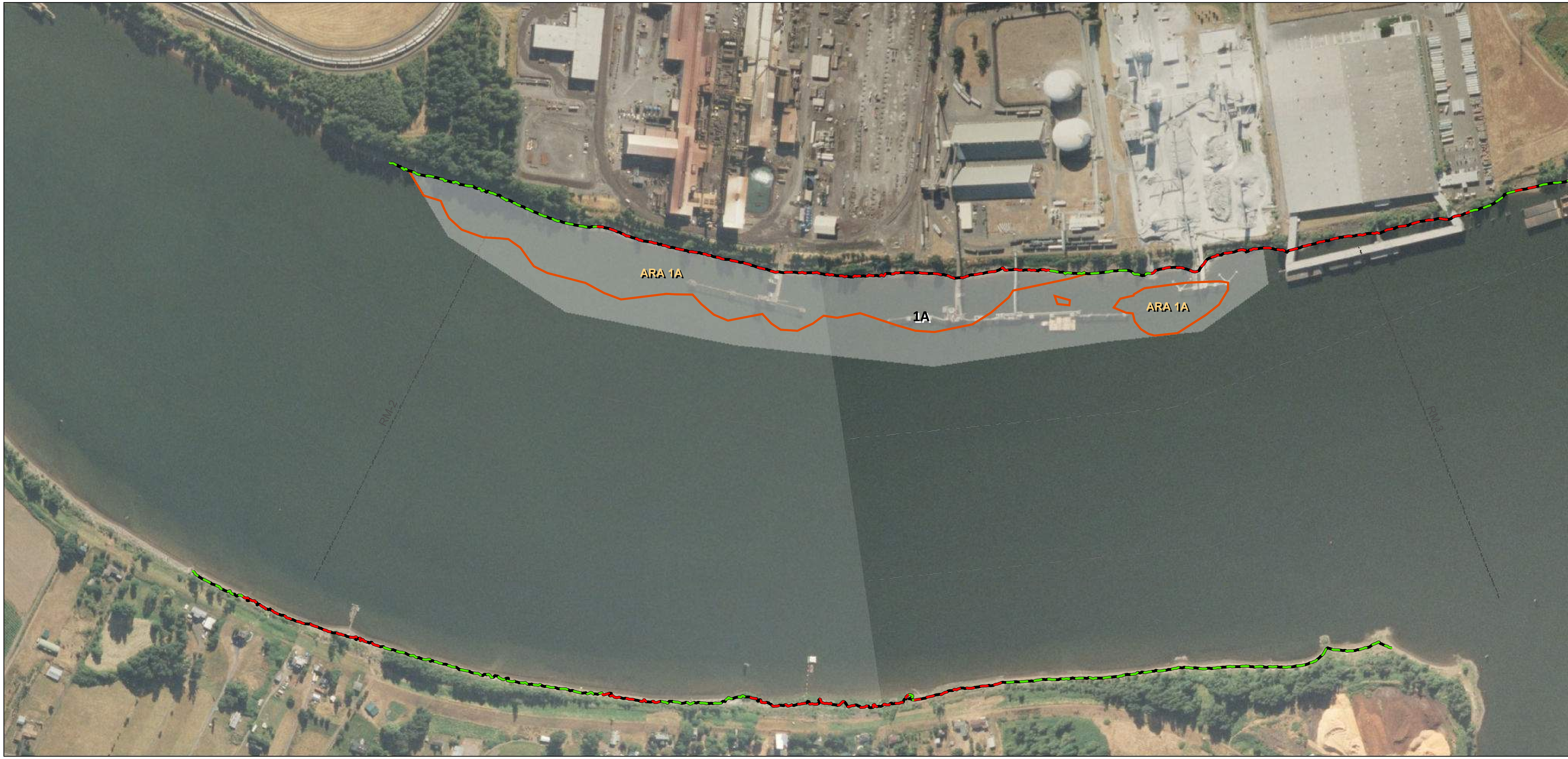
0 5 10 20
Miles

Figure 2-5. Proposed Action Area



Lower Columbia River migration timing
Lower Columbia River peak migration timing
Lower Willamette River migration timing
Lower Willamette River peak migration timing

Figure 3-1. Estimated Timing of Adult and Juvenile Salmon Presence within the Proposed Action Area



- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

Figure 4-1a. Presence of Salmonid Freshwater Migration PCEs

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- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:

1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet

0 250 500 750 1,000

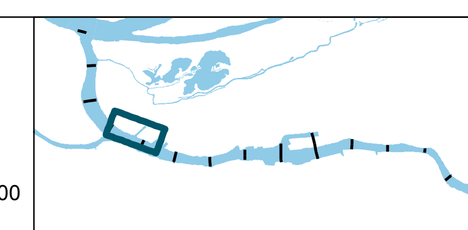

Figure 4-1b. Presence of Salmonid Freshwater Migration PCEs

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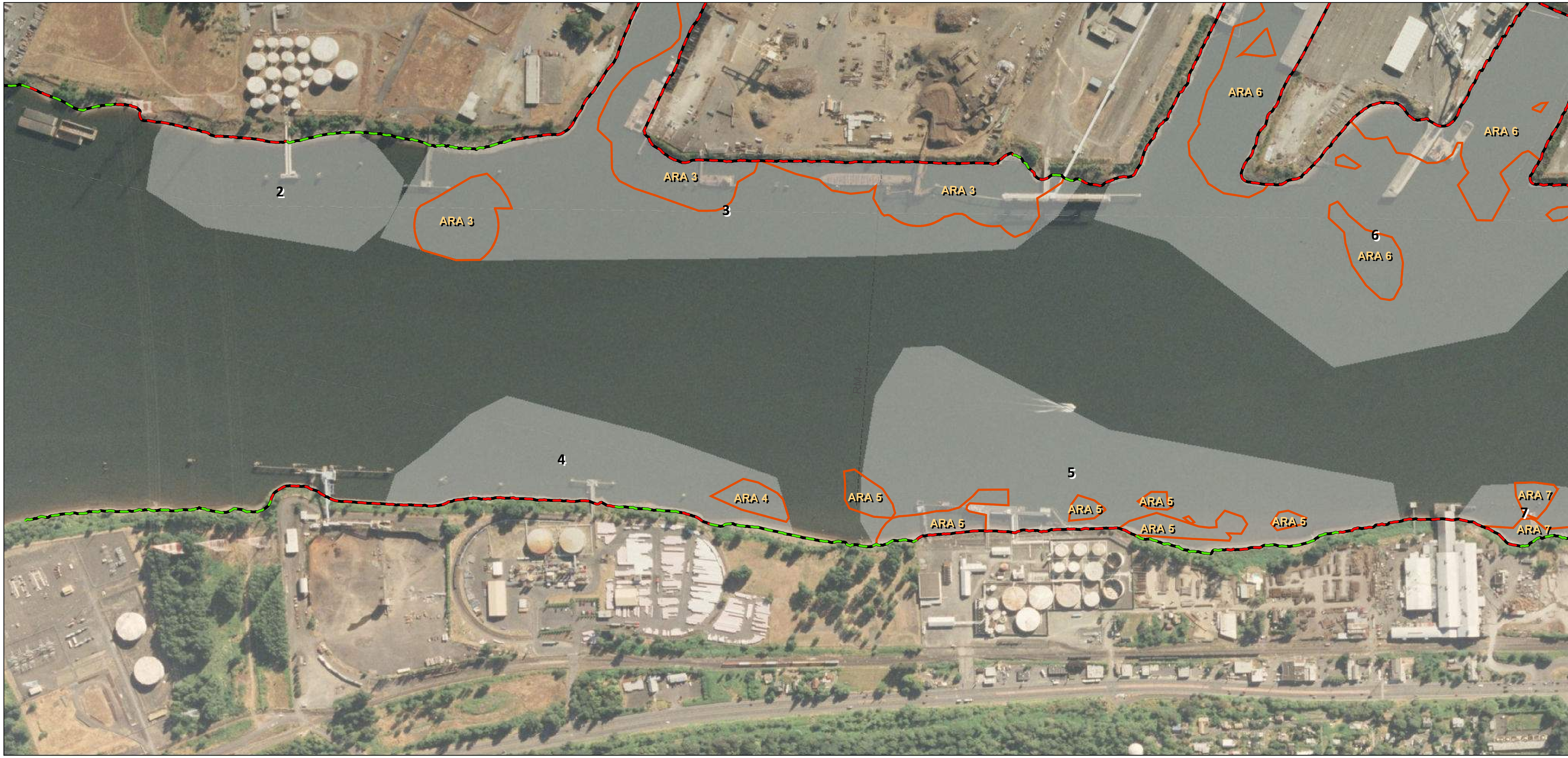


Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area

Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

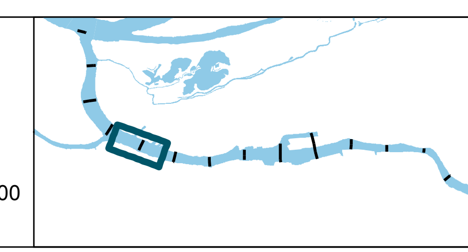


Figure 4-1c. Presence of Salmonid Freshwater Migration PCEs

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

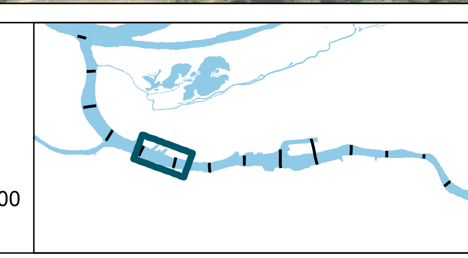
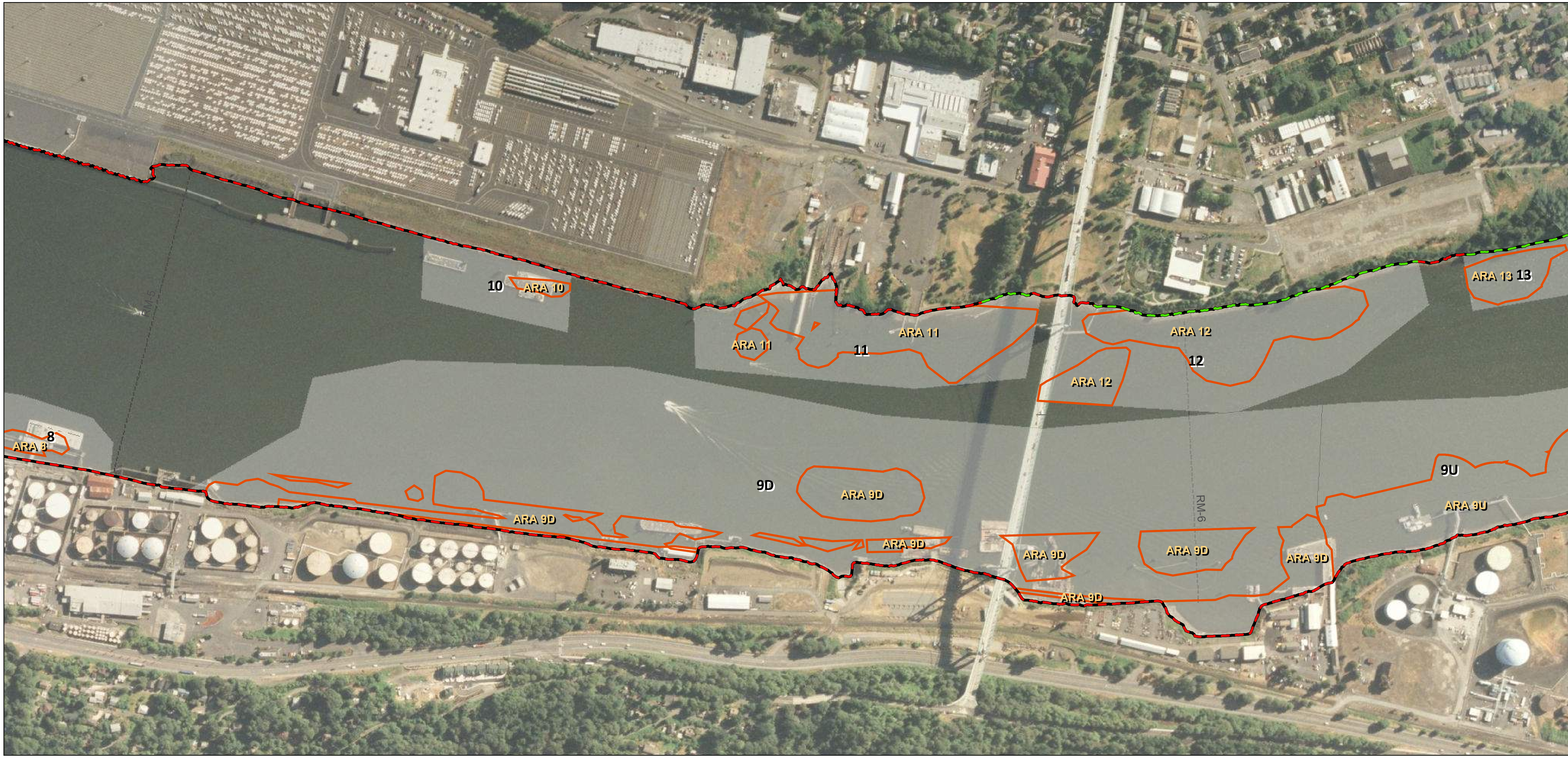


Figure 4-1d. Presence of Salmonid Freshwater Migration PCEs



- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

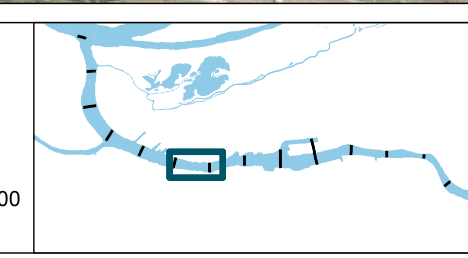
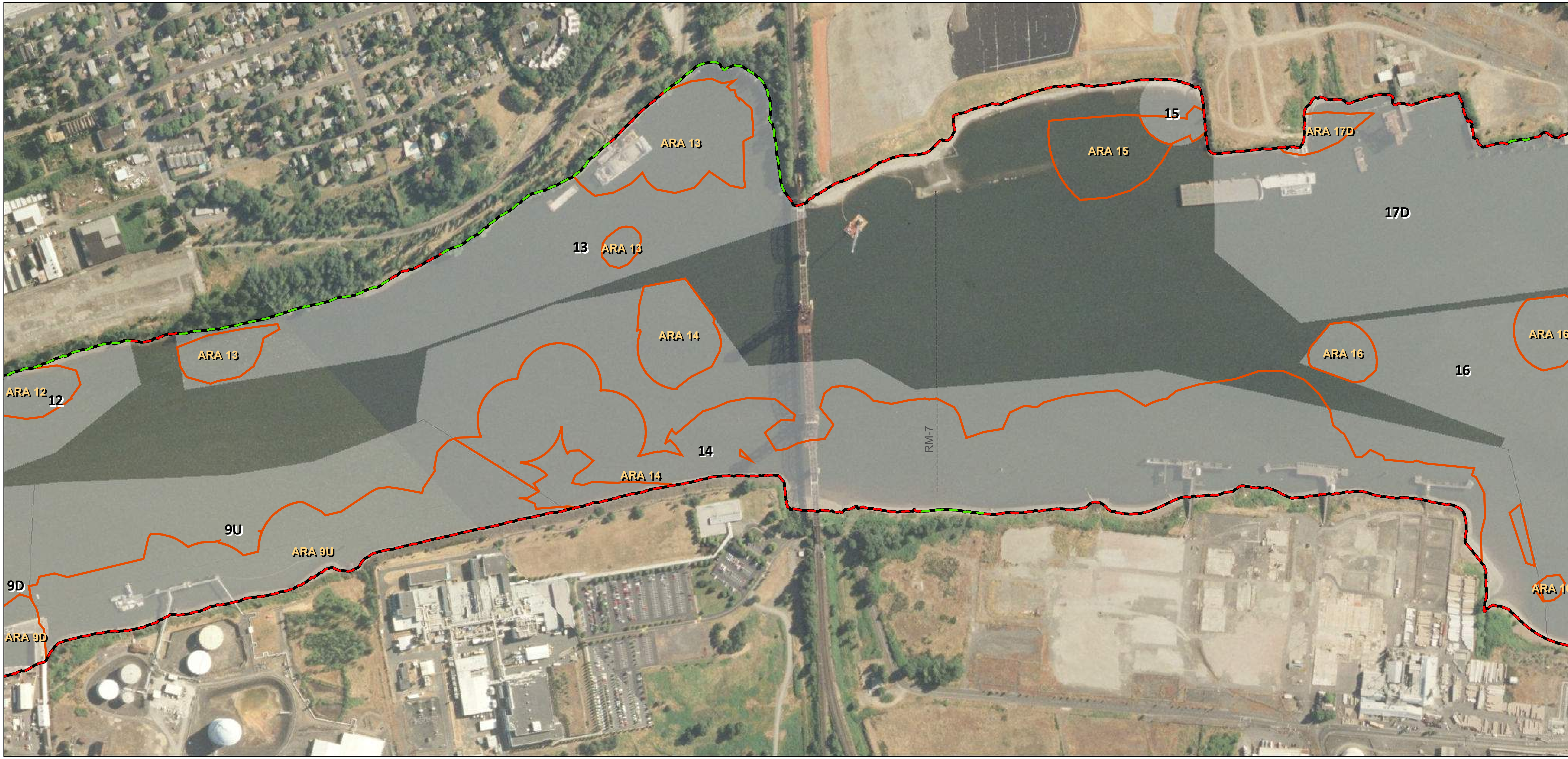


Figure 4-1e. Presence of Salmonid Freshwater Migration PCEs



- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet

0 250 500 750 1,000

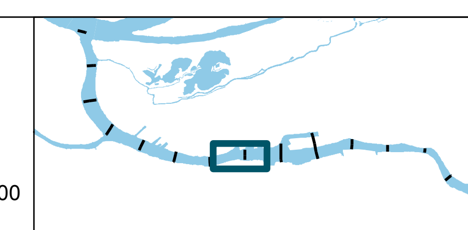


Figure 4-1f. Presence of Salmonid Freshwater Migration PCEs

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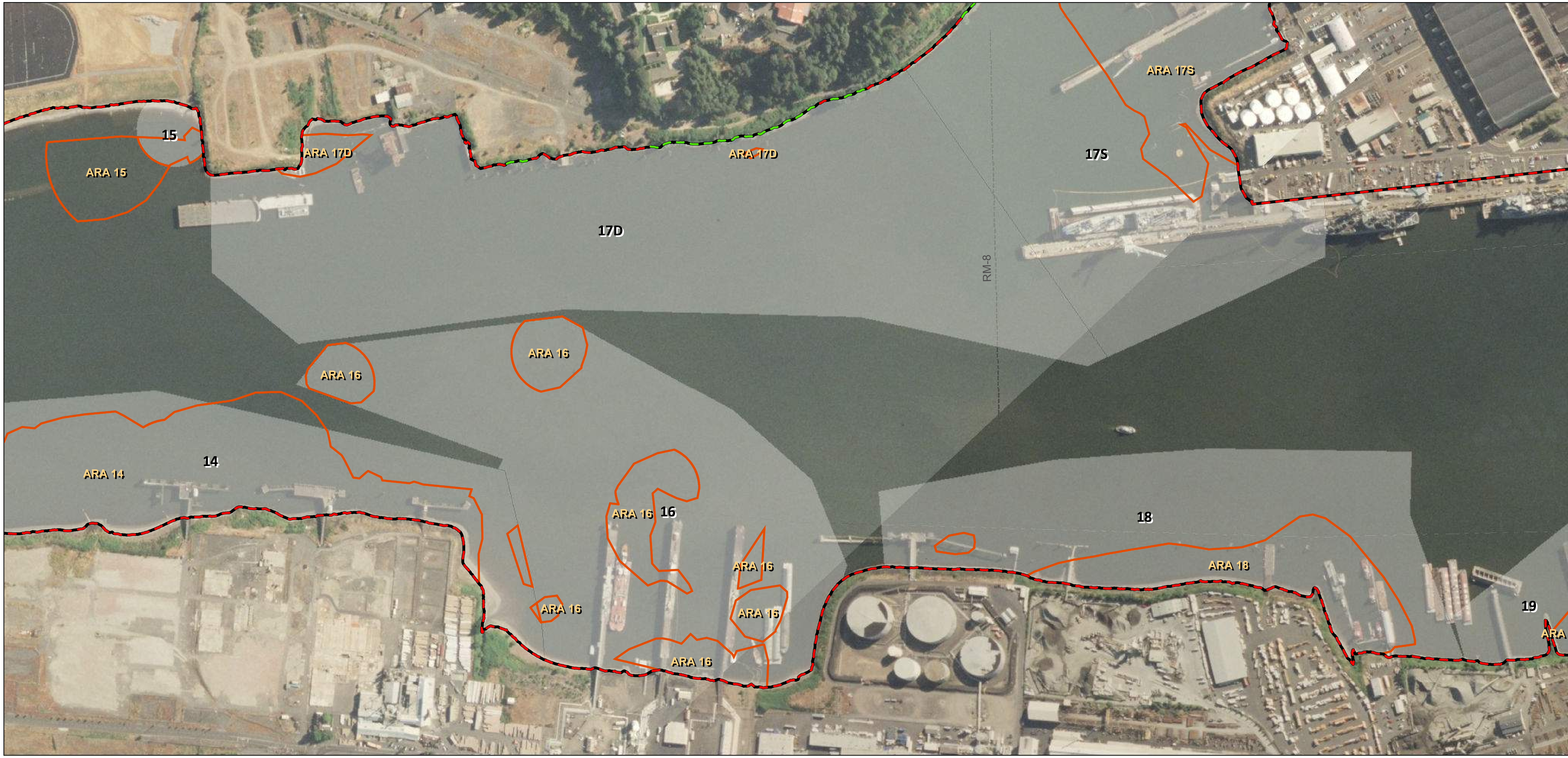

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area

Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

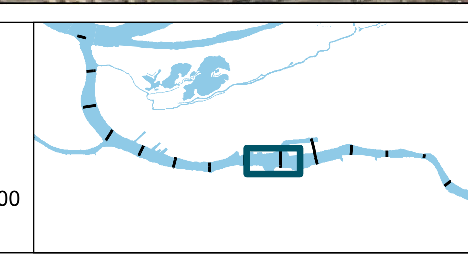

Figure 4-1g. Presence of Salmonid Freshwater Migration PCEs

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- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:

1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet

0 250 500 750 1,000

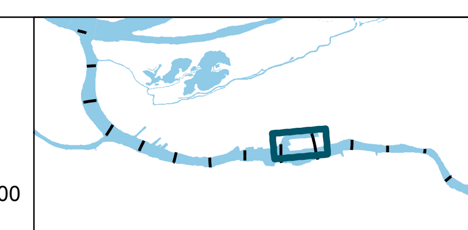

Figure 4-1h. Presence of Salmonid Freshwater Migration PCEs

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- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet

0 250 500 750 1,000

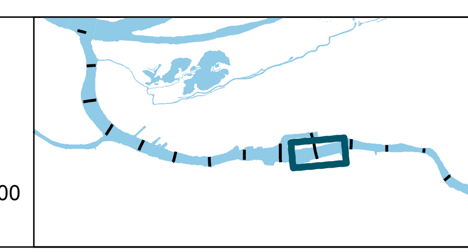

Figure 4-1i. Presence of Salmonid Freshwater Migration PCEs

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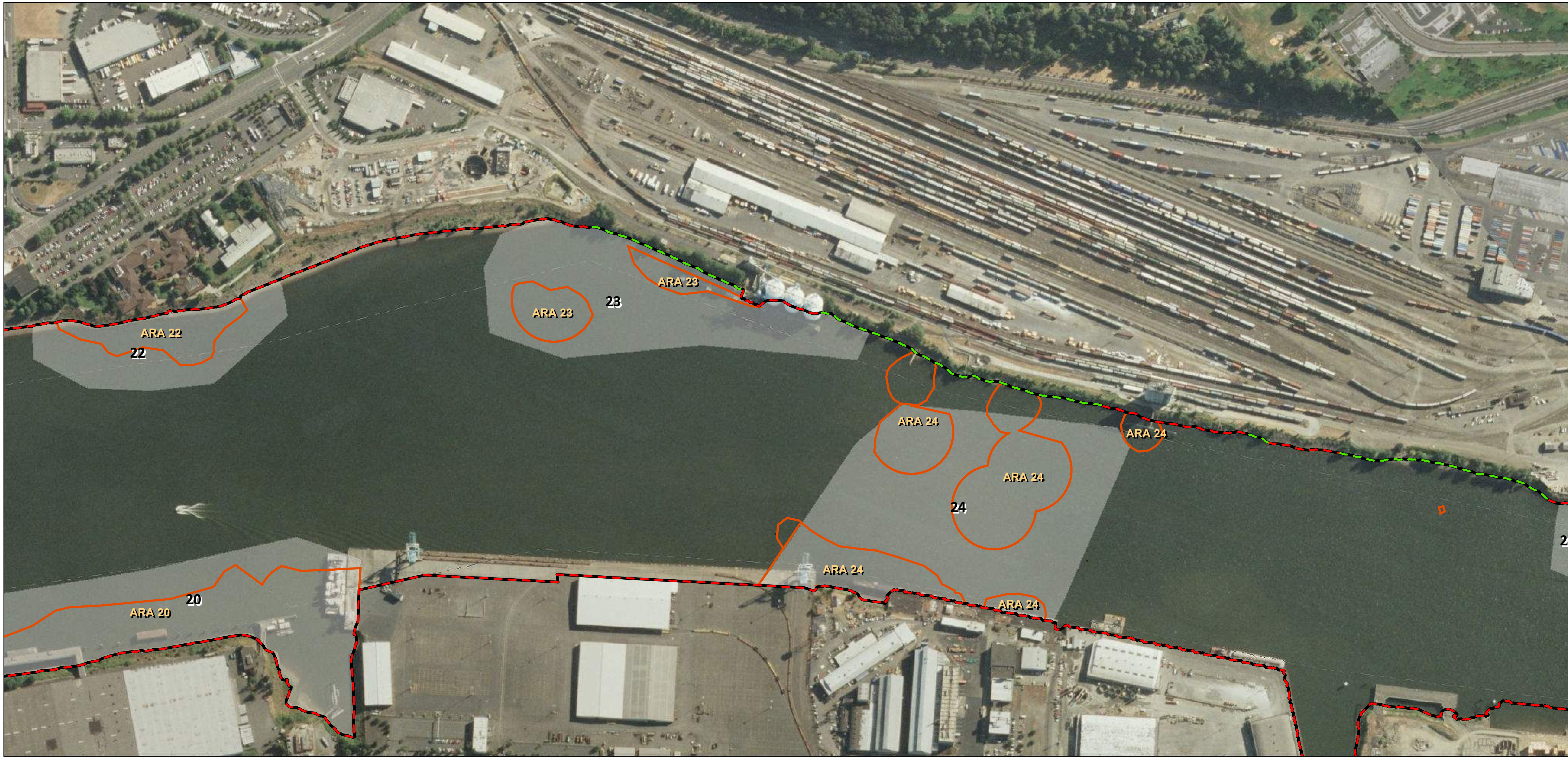

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area

Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

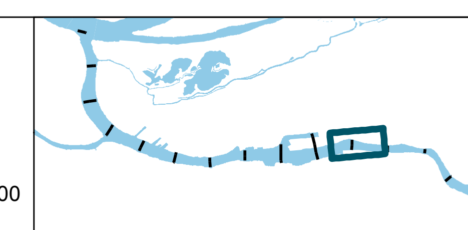

Figure 4-1j. Presence of Salmonid Freshwater Migration PCEs

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Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Free of artificial obstructions** PCE is not mapped as the entire study area contains the PCE. As with the other PCEs, the free of artificial obstructions baseline condition will be described in the text of the Programmatic BA and will discuss the presence of overwater and inwater structures as a modifying condition of the PCE.
2. **Natural cover:** the presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
3. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
4. **Water quantity** PCE is not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
5. Aerial photo: NAIP 2005.

Feet
0 250 500 750 1,000

Figure 4-1k. Presence of Salmonid Freshwater Migration PCEs

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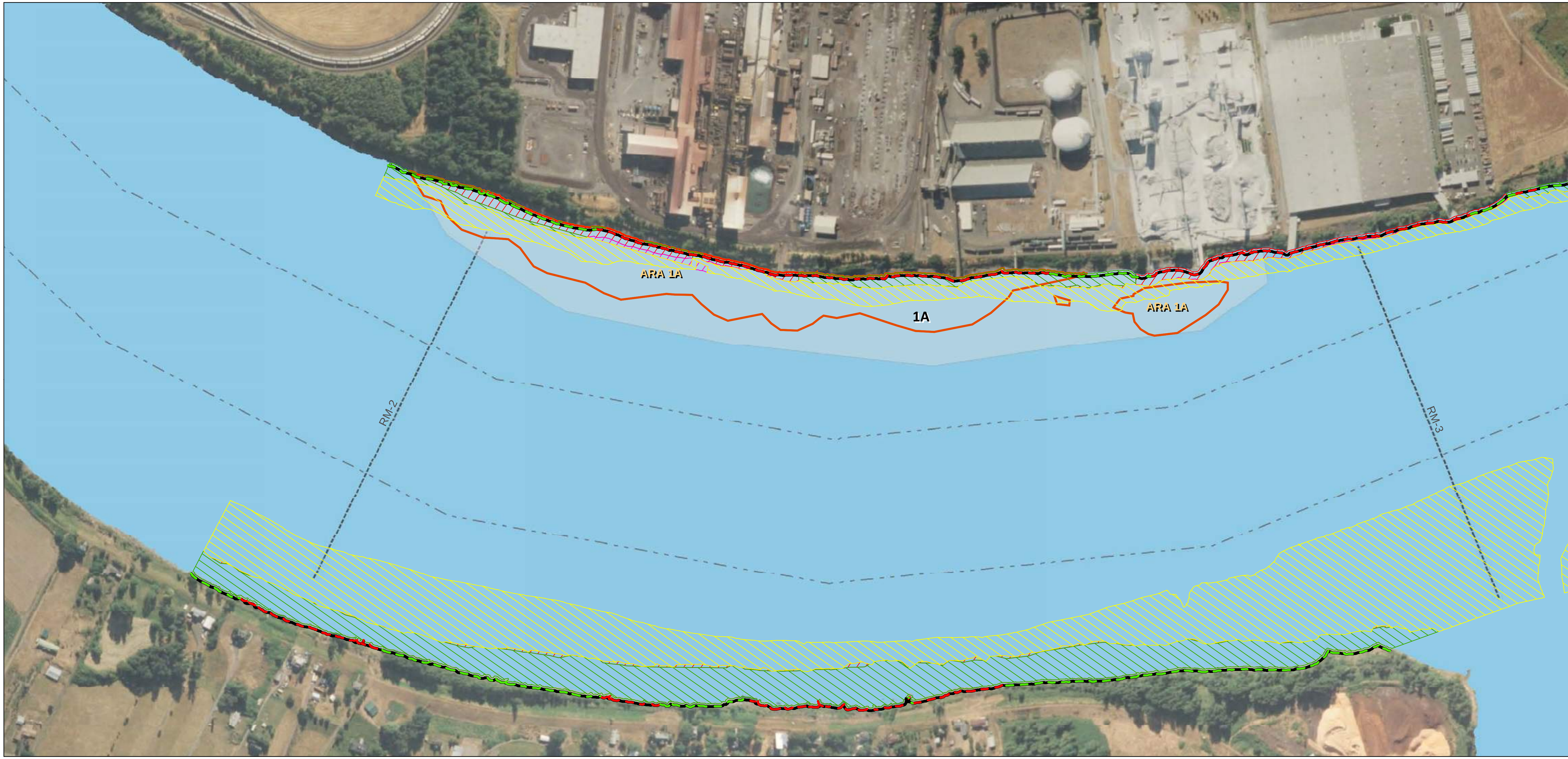

- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Forage Presence in the Active Channel Margin
- Forage Presence in the Shallow Water Zone
- Forage Absence in the Active Channel Margin
- Forage Absence in the Shallow Water Zone
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:
1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

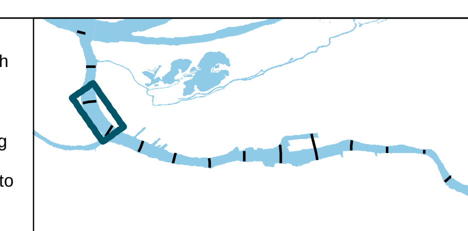

Figure 4-2a. Presence of Salmonid Freshwater Rearing PCEs

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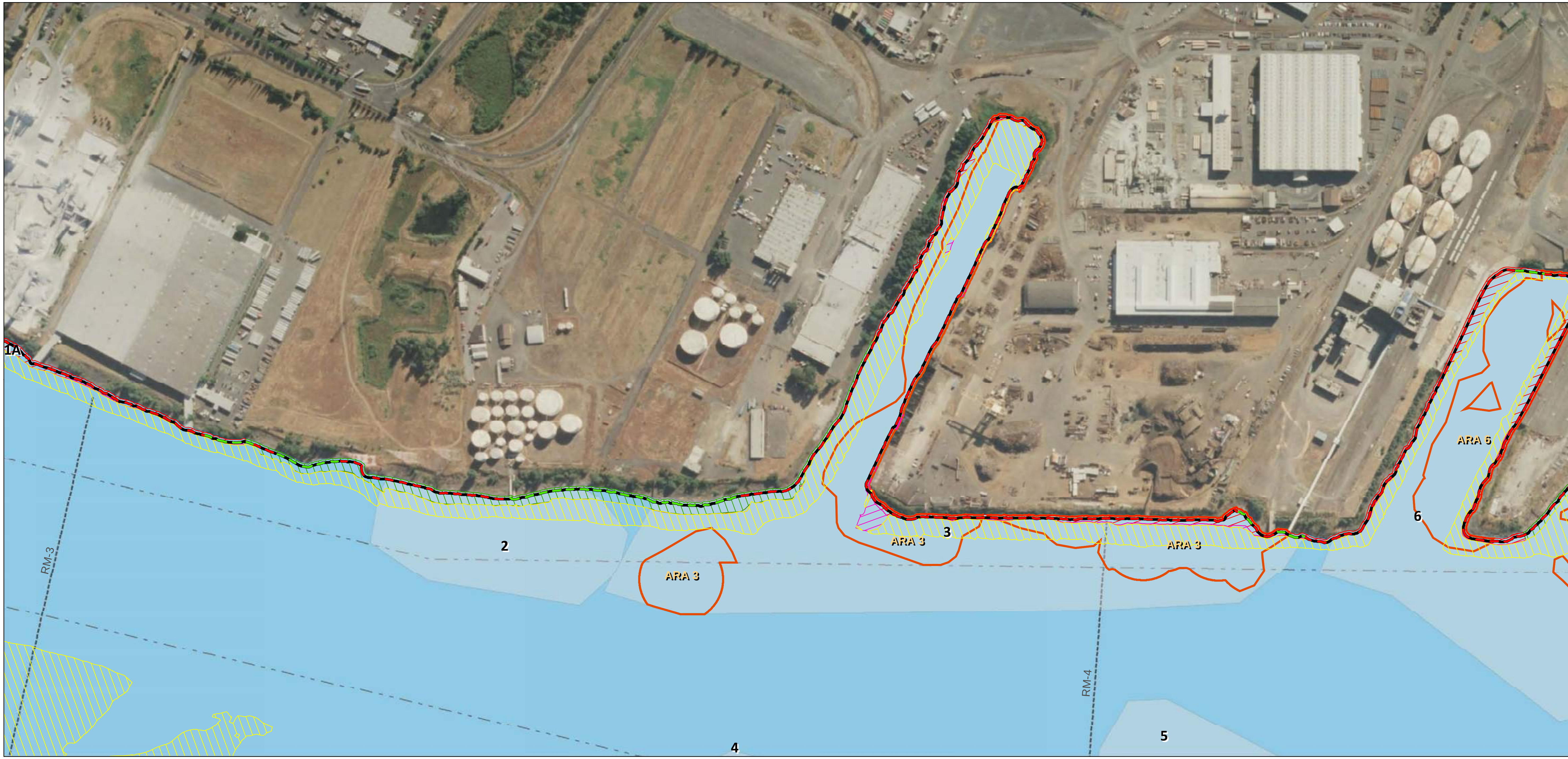

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

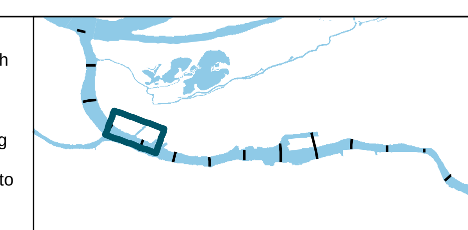

Figure 4-2b. Presence of Salmonid Freshwater Rearing PCEs

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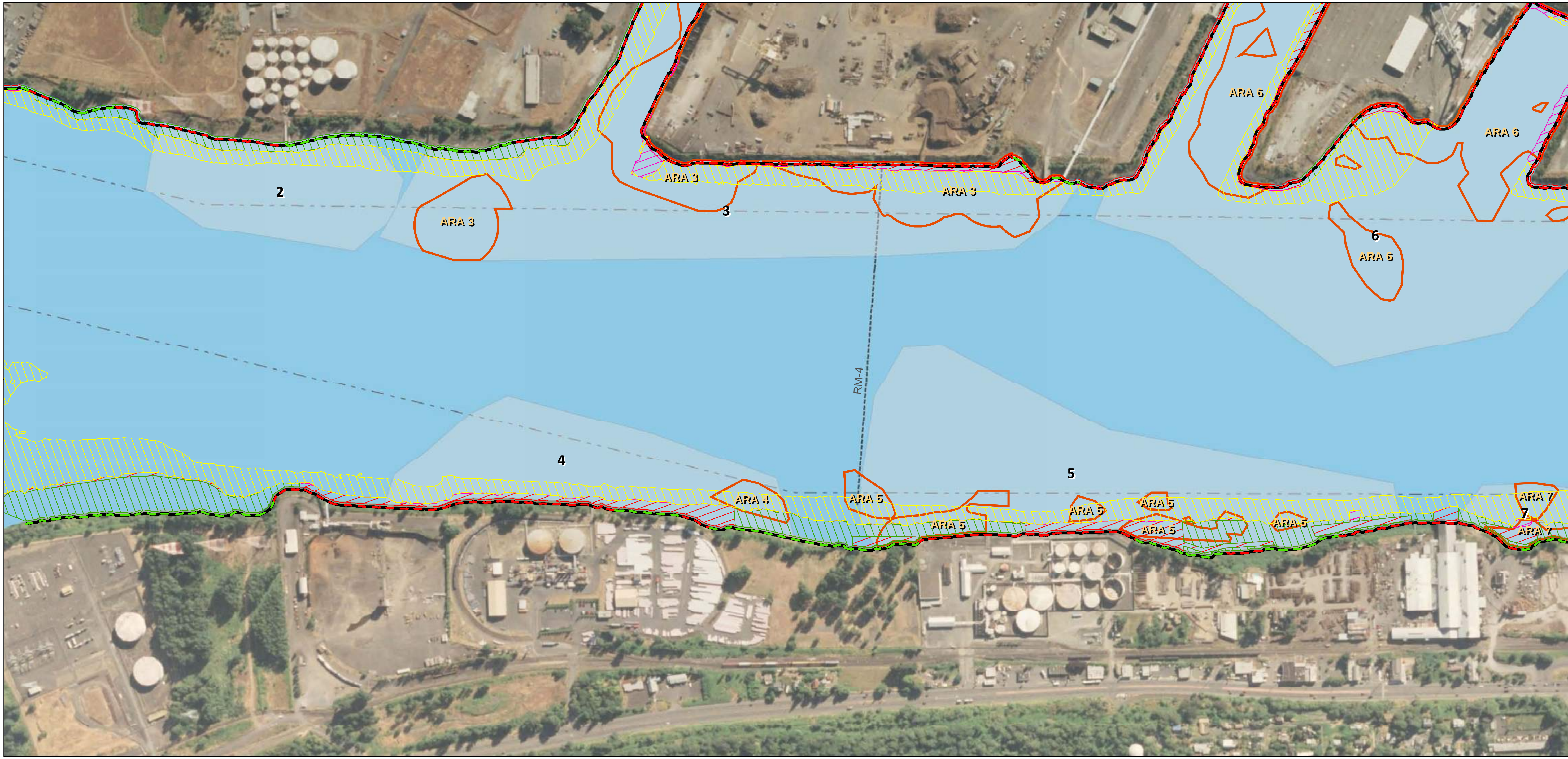

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:

1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

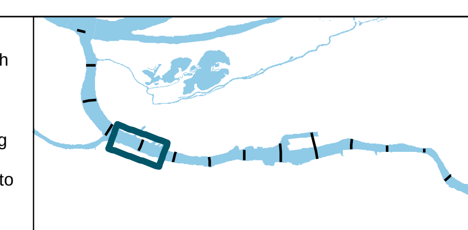

Figure 4-2c. Presence of Salmonid Freshwater Rearing PCEs

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Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

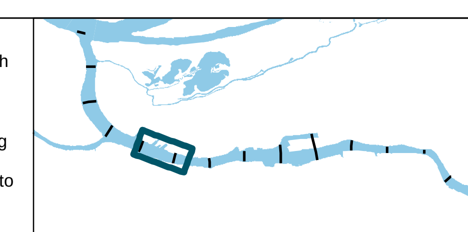

Figure 4-2d. Presence of Salmonid Freshwater Rearing PCEs

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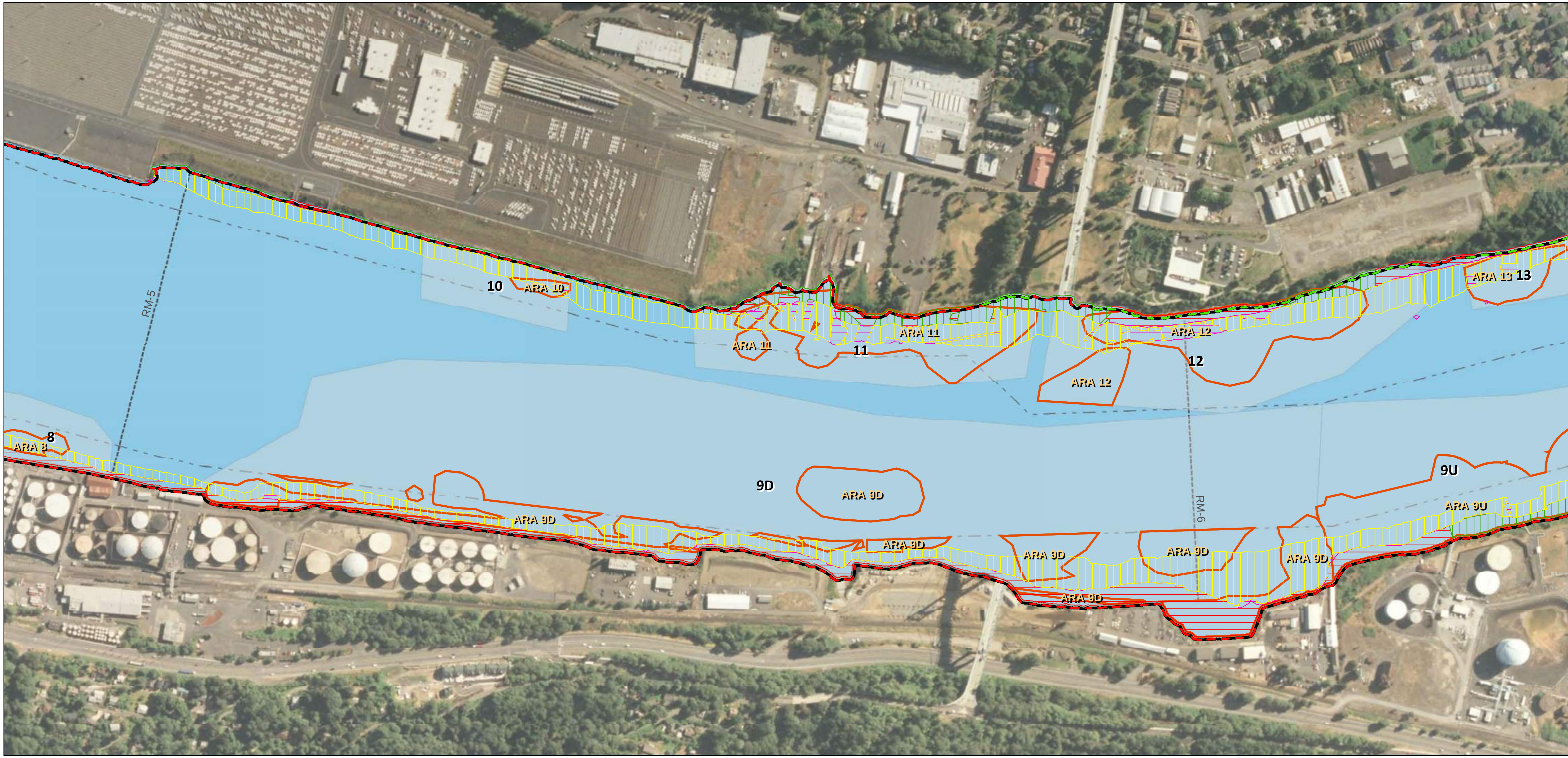

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:

1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

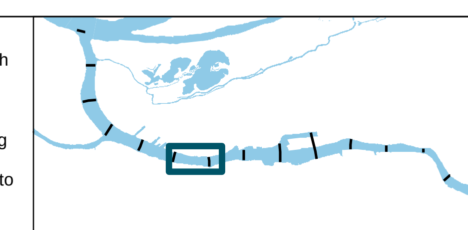

Figure 4-2e. Presence of Salmonid Freshwater Rearing PCEs

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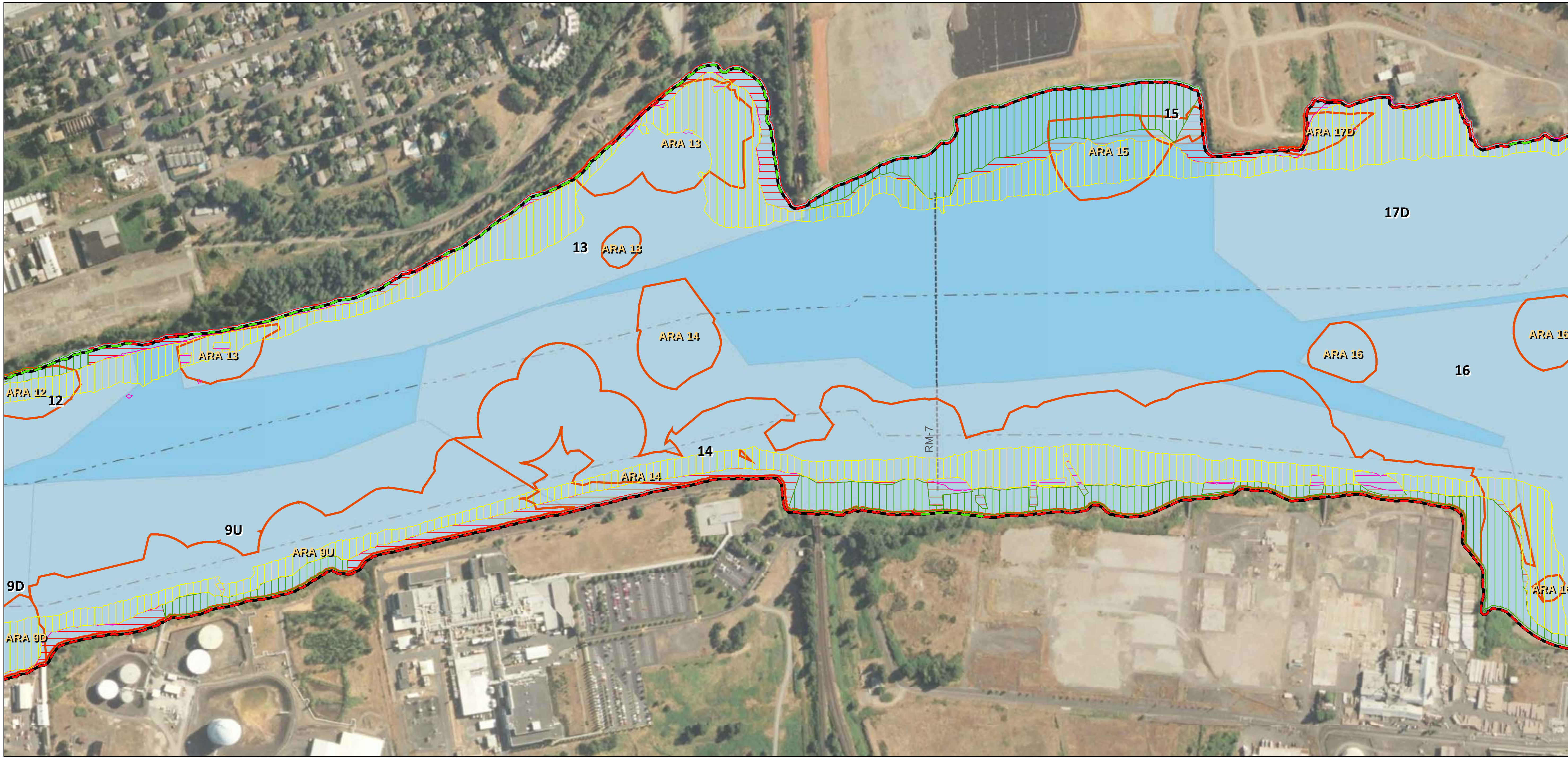


Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:

1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

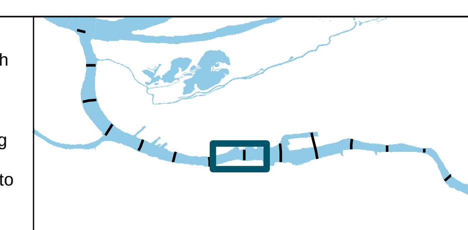
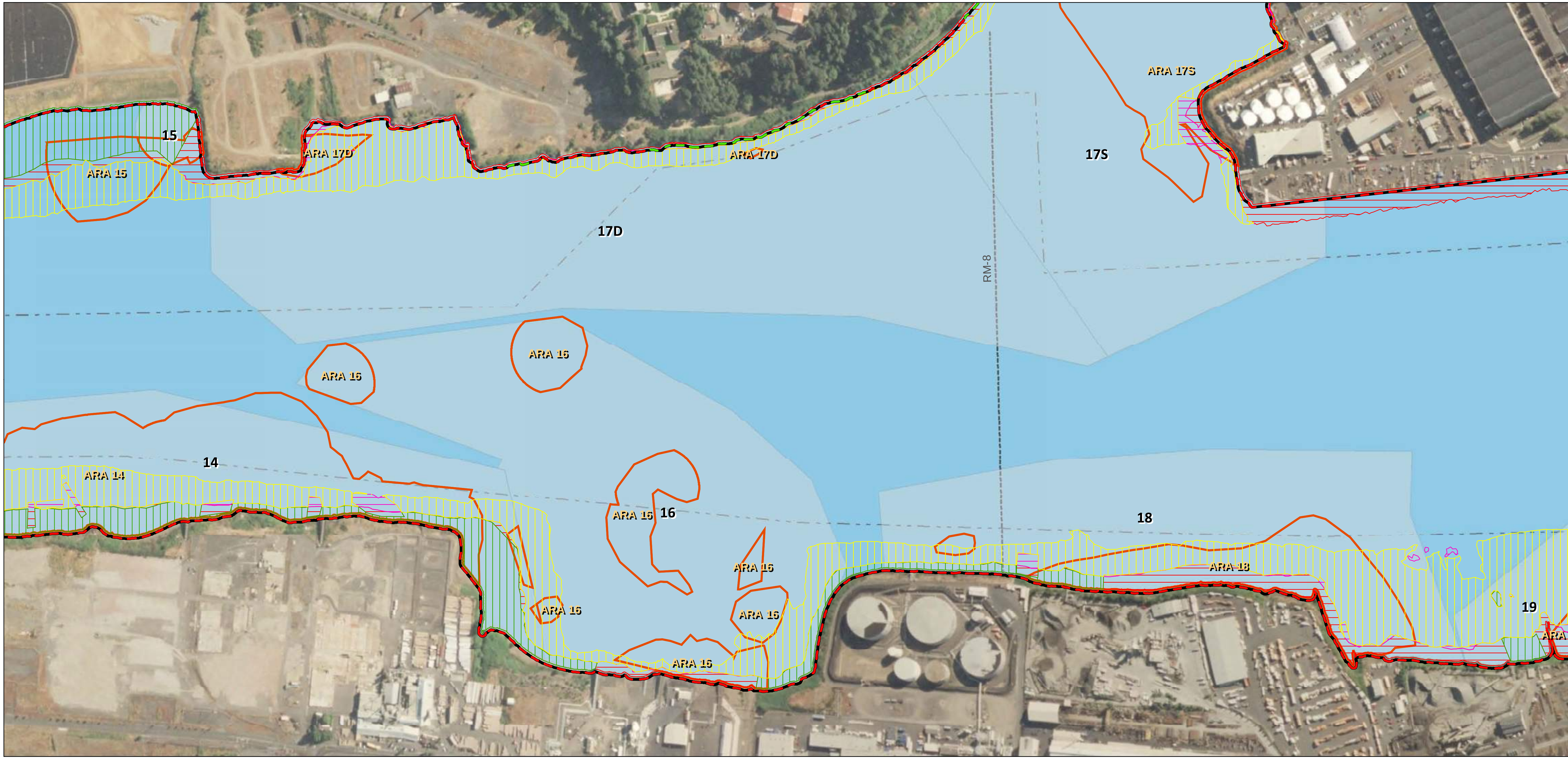


Figure 4-2f. Presence of Salmonid Freshwater Rearing PCEs



Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:

1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

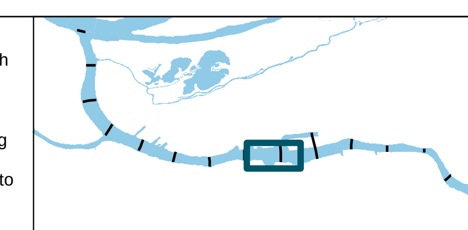


Figure 4-2g. Presence of Salmonid Freshwater Rearing PCEs

Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone
Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:

1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

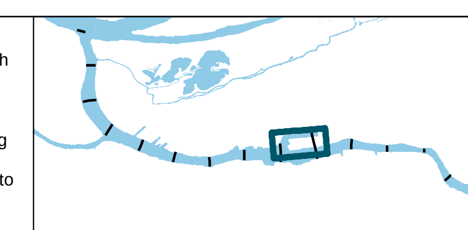


Figure 4-2h. Presence of Salmonid Freshwater Rearing PCEs

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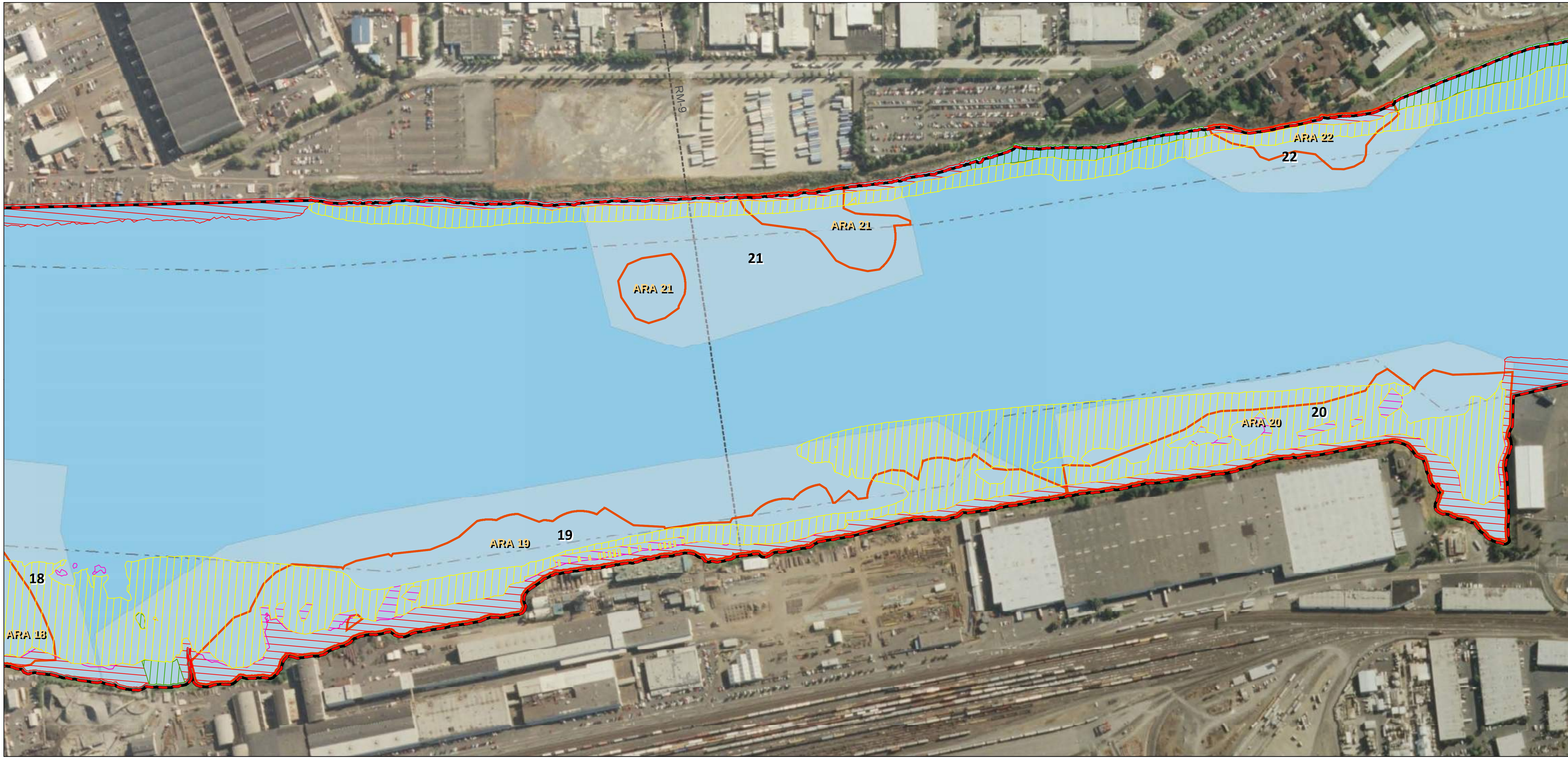


Presence of Natural Cover in Study Area
Absence of Natural Cover in Study Area
Forage Presence in the Active Channel Margin
Forage Presence in the Shallow Water Zone
Forage Absence in the Active Channel Margin
Forage Absence in the Shallow Water Zone

Active Remediation Areas
Areas of Potential Concern (August 2011)
Navigation Channel
River miles

NOTES:
1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

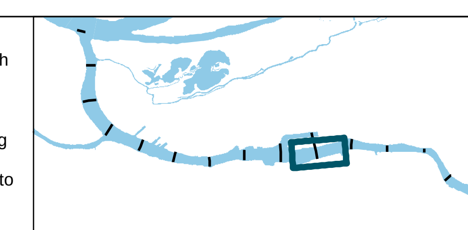
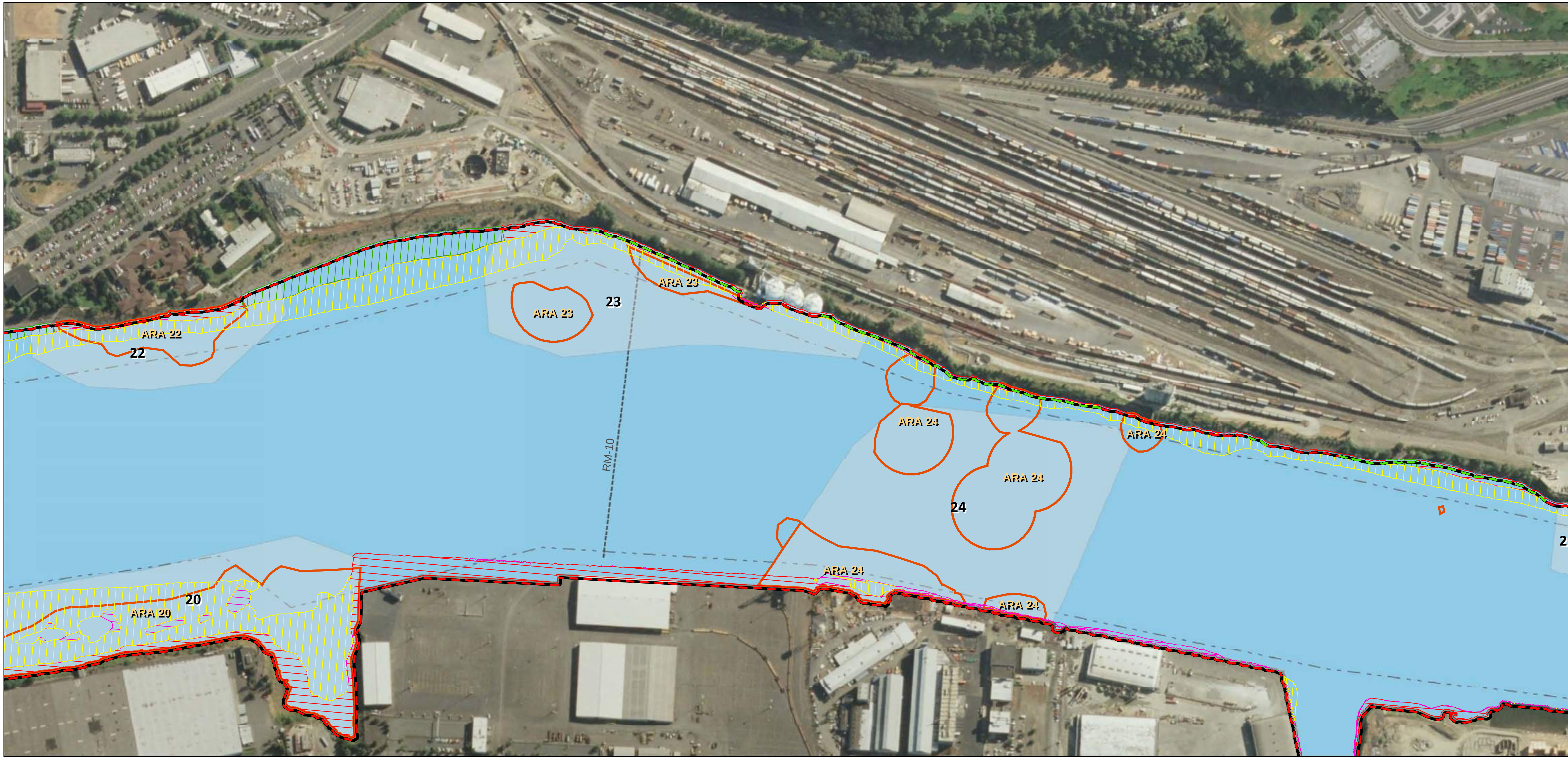


Figure 4-2i. Presence of Salmonid Freshwater Rearing PCEs



- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Forage Presence in the Active Channel Margin
- Forage Presence in the Shallow Water Zone
- Forage Absence in the Active Channel Margin
- Forage Absence in the Shallow Water Zone
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:

1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

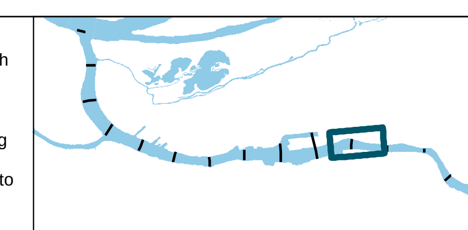


Figure 4-2j. Presence of Salmonid Freshwater Rearing PCEs

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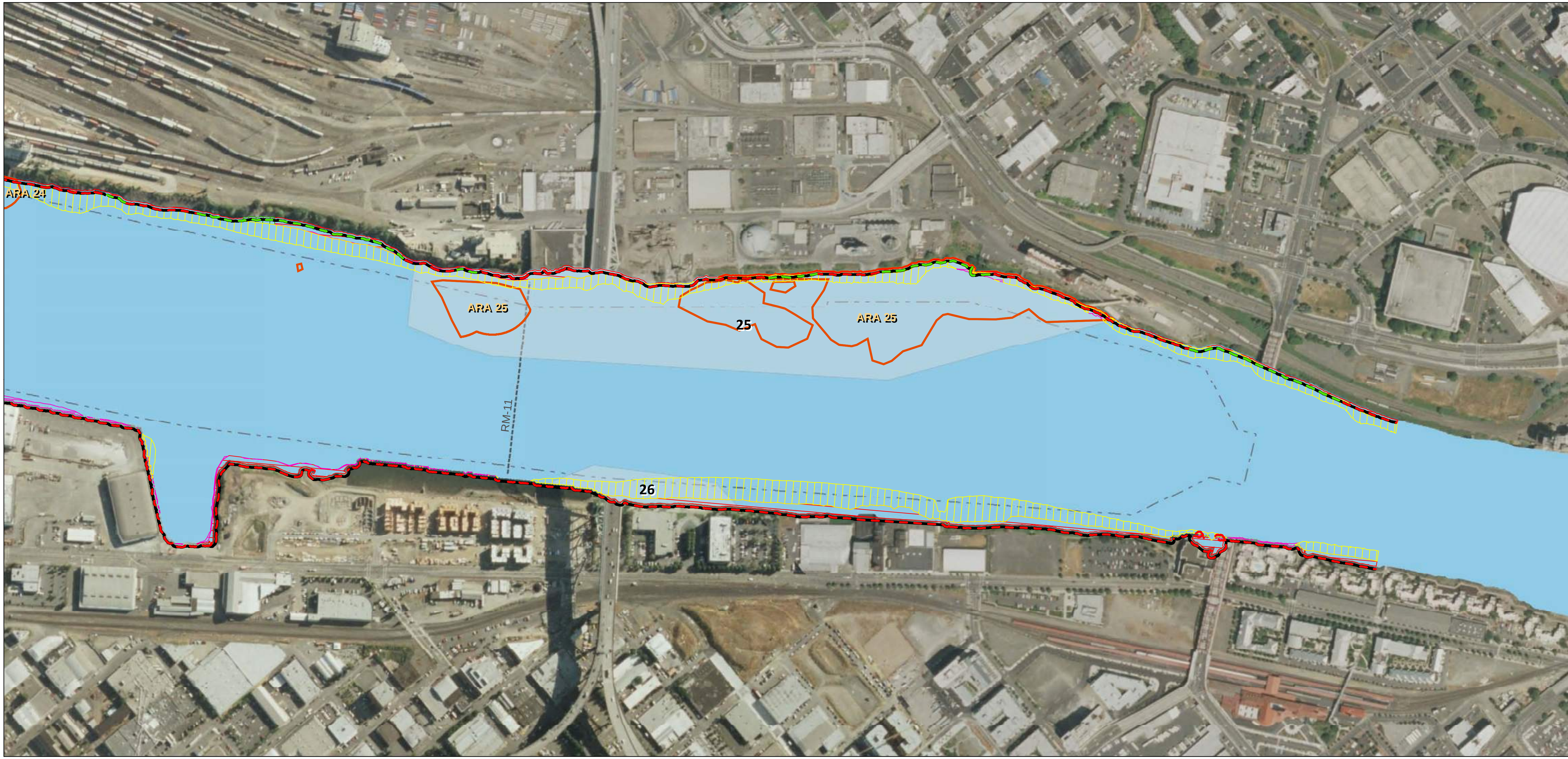

- Presence of Natural Cover in Study Area
- Absence of Natural Cover in Study Area
- Forage Presence in the Active Channel Margin
- Forage Presence in the Shallow Water Zone
- Forage Absence in the Active Channel Margin
- Forage Absence in the Shallow Water Zone
- Active Remediation Areas
- Areas of Potential Concern (August 2011)
- Navigation Channel
- River miles

NOTES:
1. **Floodplain connectivity** presence/absence is not mapped as the entire study area does not contain the PCE due to filling, flood control, and other activities that have separated the floodplain from the river.
2. **Forage in the ACM:** presence of forage PCE in the ACM is indicated by unarmored beach (beach, bioengineered) as determined by the shoreline condition dataset developed by Integral for the study area, and small substrate size (i.e., no riprap, fill, or debris covering the substrate).
3. **Forage in shallow water areas:** presence of forage PCE is indicated by shallow water zones (20 feet below ordinary low water elevation) with small substrate size (<64 mm; i.e., no debris covering the substrate).
4. **Natural cover:** presence of natural cover PCE is indicated by the presence of a riparian area with mature trees/shrubs with woody stems that overhang the ACM and presence of large woody debris (LWD) accumulations as determined from photo-interpretation of 2005 aerial photographs.
5. **Water quality** PCE presence/absence is not mapped. As with the other PCEs, the water quality baseline will be described in the text of the Programmatic BA using water quality indicators including ecological risk exceedances and benthic toxicity areas and the DEQ 303(d) list.
6. **Water quantity** PCE not mapped as the entire study area has impacted flow and hydrology due to the operation of upstream dams.
7. Aerial photo: NAIP 2005.

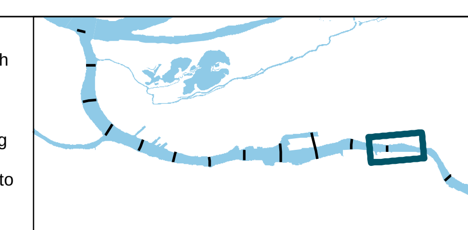

Figure 4-2k. Presence of Salmonid Freshwater Rearing PCEs

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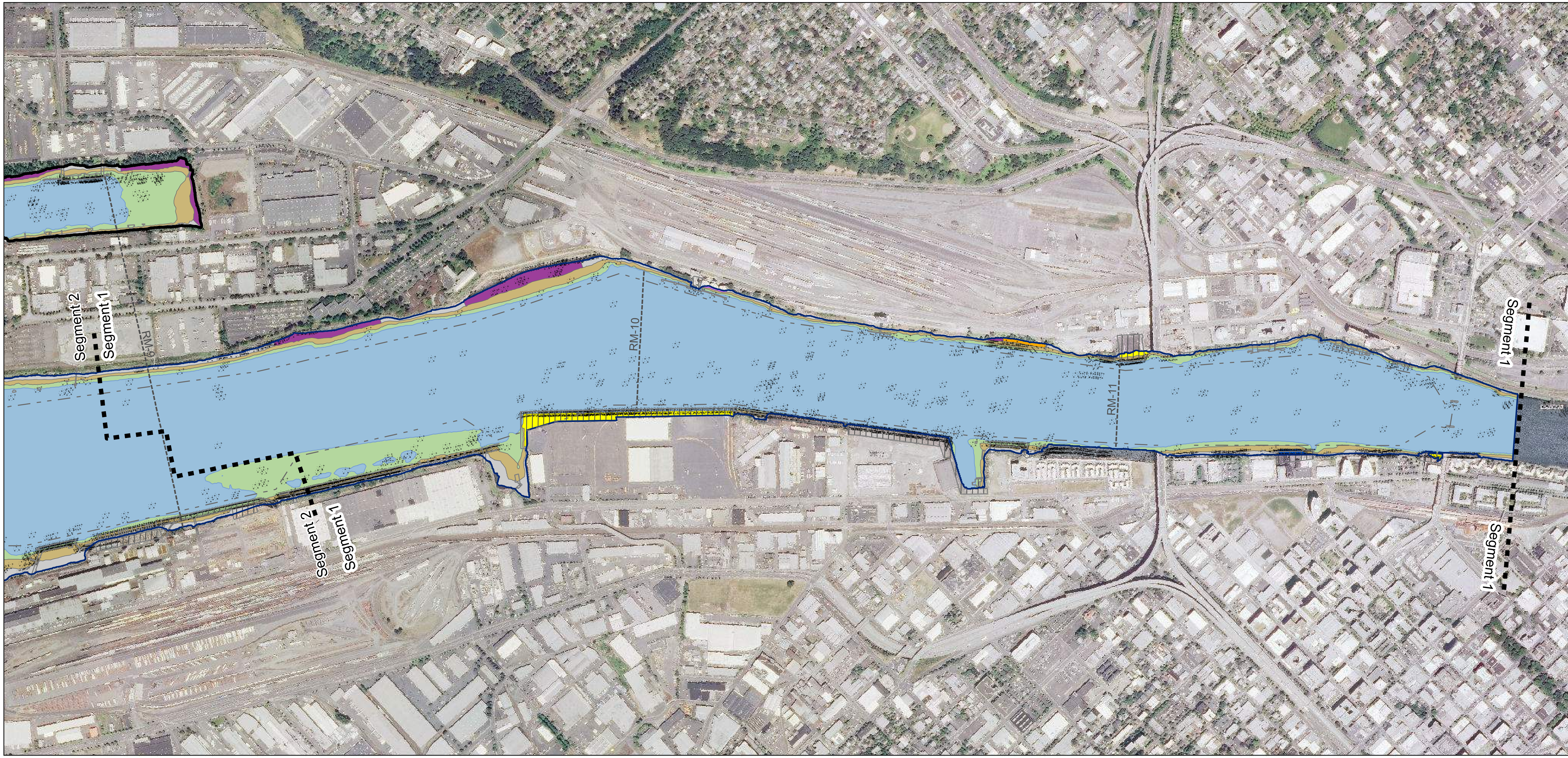

LEGEND

Active Channel Margin Shoreline Type

- Beach
- Bio-Engineered
- Pilings - Allowing Light
- Pilings - Limiting Light
- Rip Rap
- Rock
- Seawall
- Shallow Water Nearshore (5.1 to -4.9 ft NAVD88)
- Shallow Main Channel (-4.9 to -14.9 ft NAVD88)
- Deep Water (> -14.9 ft NAVD88)
- Debris
- Over Water Structures
- Portland Harbor Study Area
- Federal Navigation Channel
- River miles
- Segment Boundary

Feet

0 550 1,100 1,650 2,200

AERIAL PHOTO: RLIS 2007.

Figure 4-3a. Existing Shoreline and Water Depth Conditions

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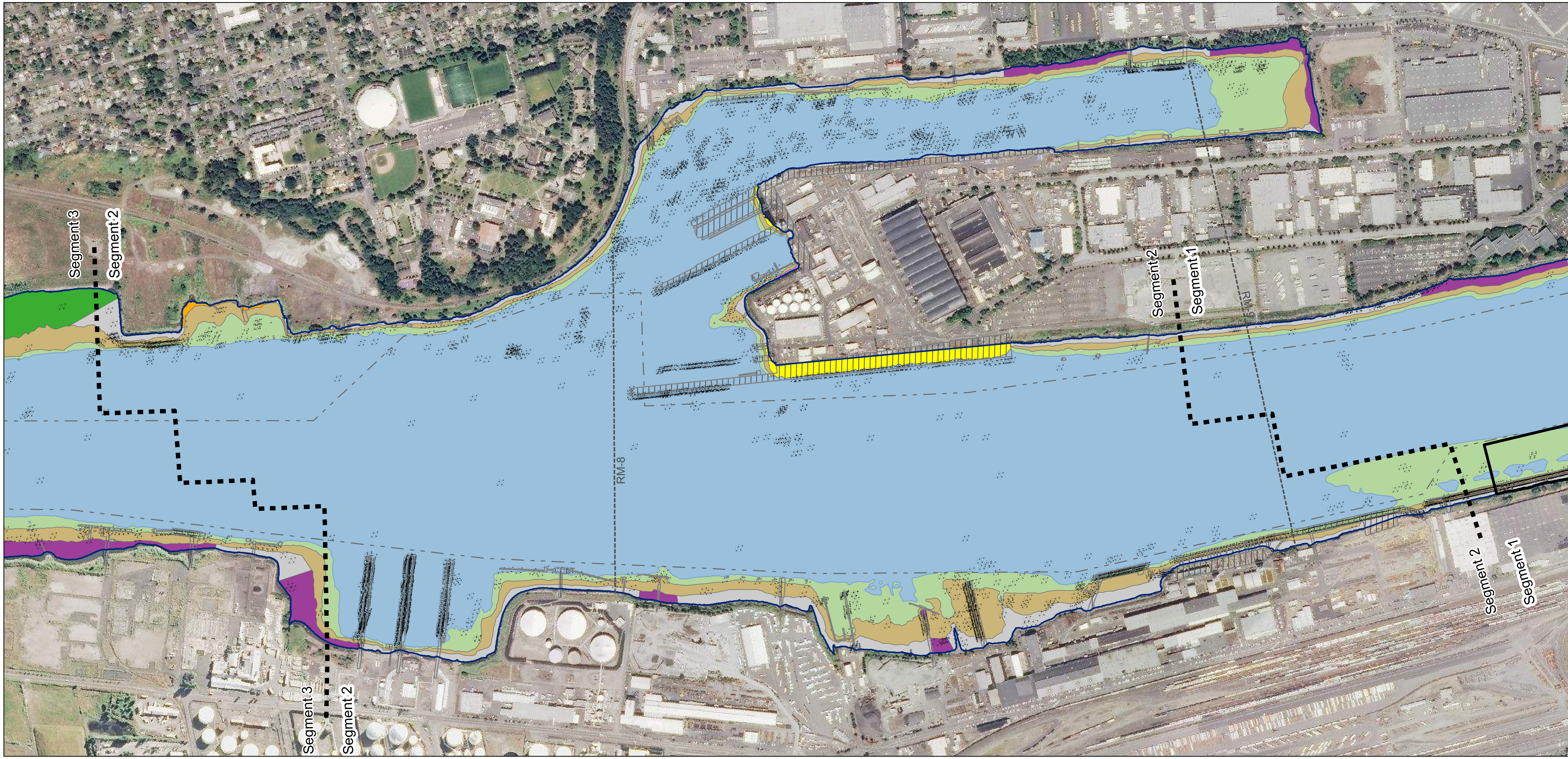

LEGEND

Active Channel Margin Shoreline Type

- Beach
- Bio-Engineered
- Pilings - Allowing Light
- Pilings - Limiting Light
- Rip Rap
- Rock
- Seawall
- Shallow Water Nearshore (5.1 to -4.9 ft NAVD88)
- Shallow Main Channel (-4.9 to -14.9 ft NAVD88)
- Deep Water (> -14.9 ft NAVD88)
- Debris
- Over Water Structures
- Portland Harbor Study Area
- Federal Navigation Channel
- River miles
- Segment Boundary

Feet

0 400 800 1,200 1,600

AERIAL PHOTO: RLIS 2007.

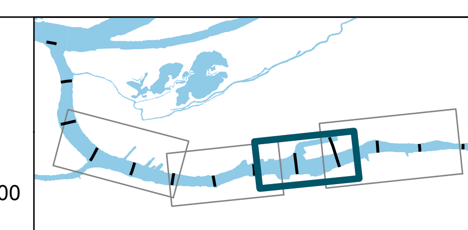

Figure 4-3b. Existing Shoreline and Water Depth Conditions

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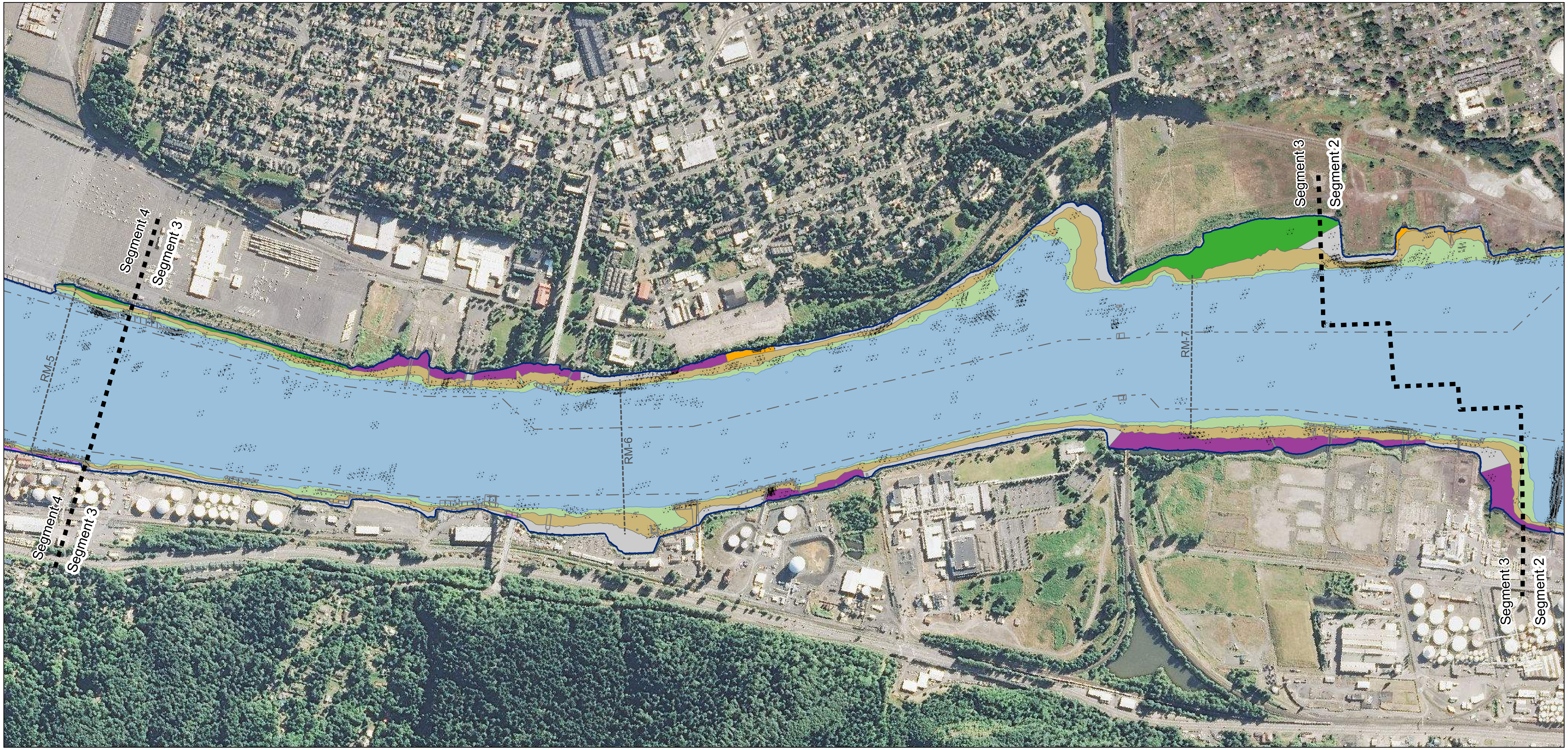


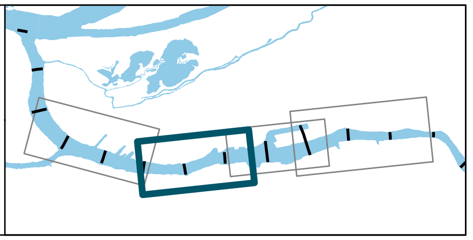
LEGEND

Active Channel Margin Shoreline Type

- Beach
- Bio-Engineered
- Pilings - Allowing Light
- Pilings - Limiting Light
- Rip Rap
- Rock
- Seawall
- Shallow Water Nearshore (5.1 to -4.9 ft NAVD88)
- Shallow Main Channel (-4.9 to -14.9 ft NAVD88)
- Deep Water (> -14.9 ft NAVD88)
- Debris
- Over Water Structures
- Portland Harbor Study Area
- Federal Navigation Channel
- River miles
- Segment Boundary

Feet

0 450 900 1,350 1,800



AERIAL PHOTO: RLIS 2007.

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Figure 4-3c. Existing Shoreline and Water Depth Conditions

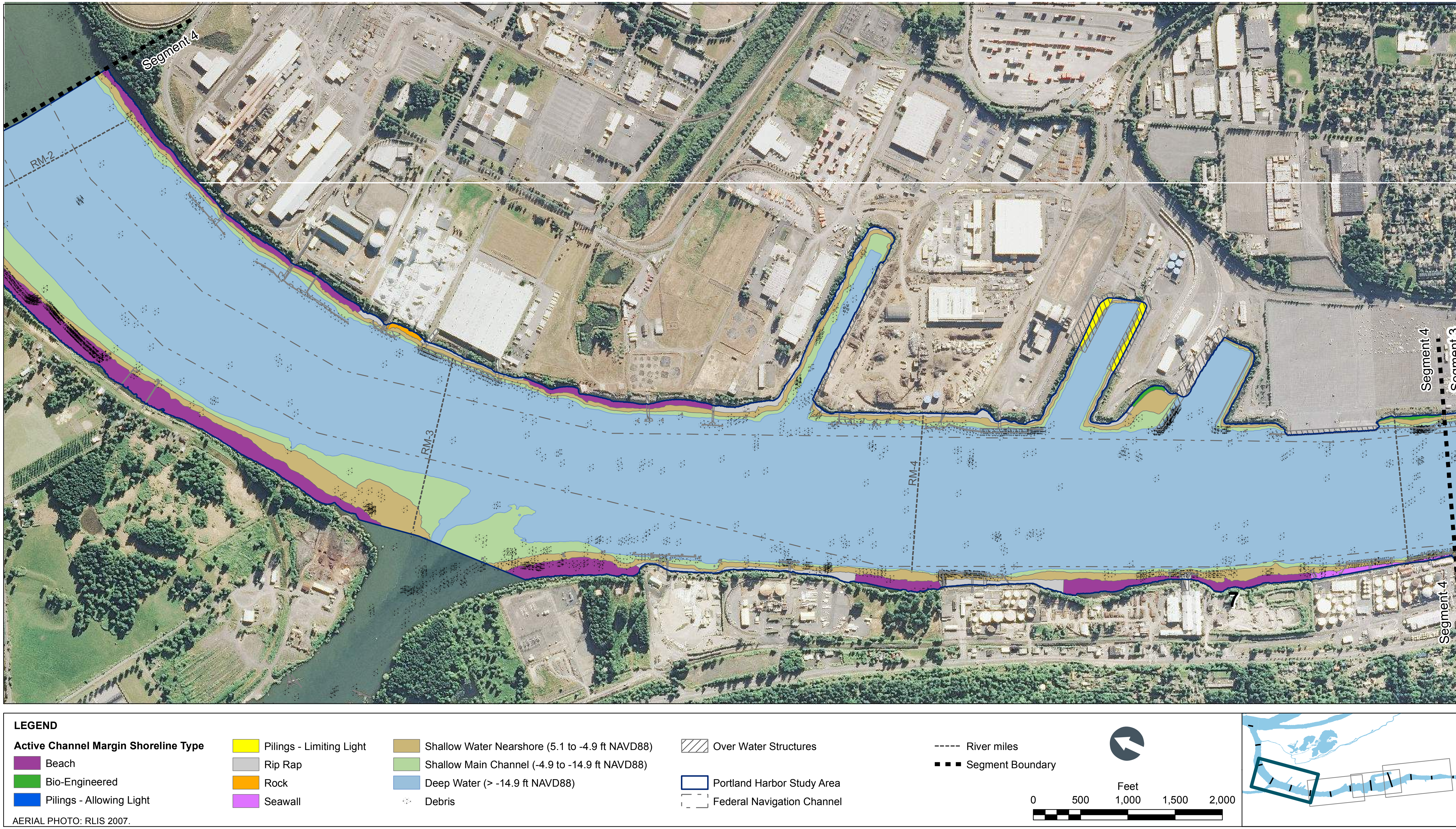

Figure 4-3d. Existing Shoreline and Water Depth Conditions

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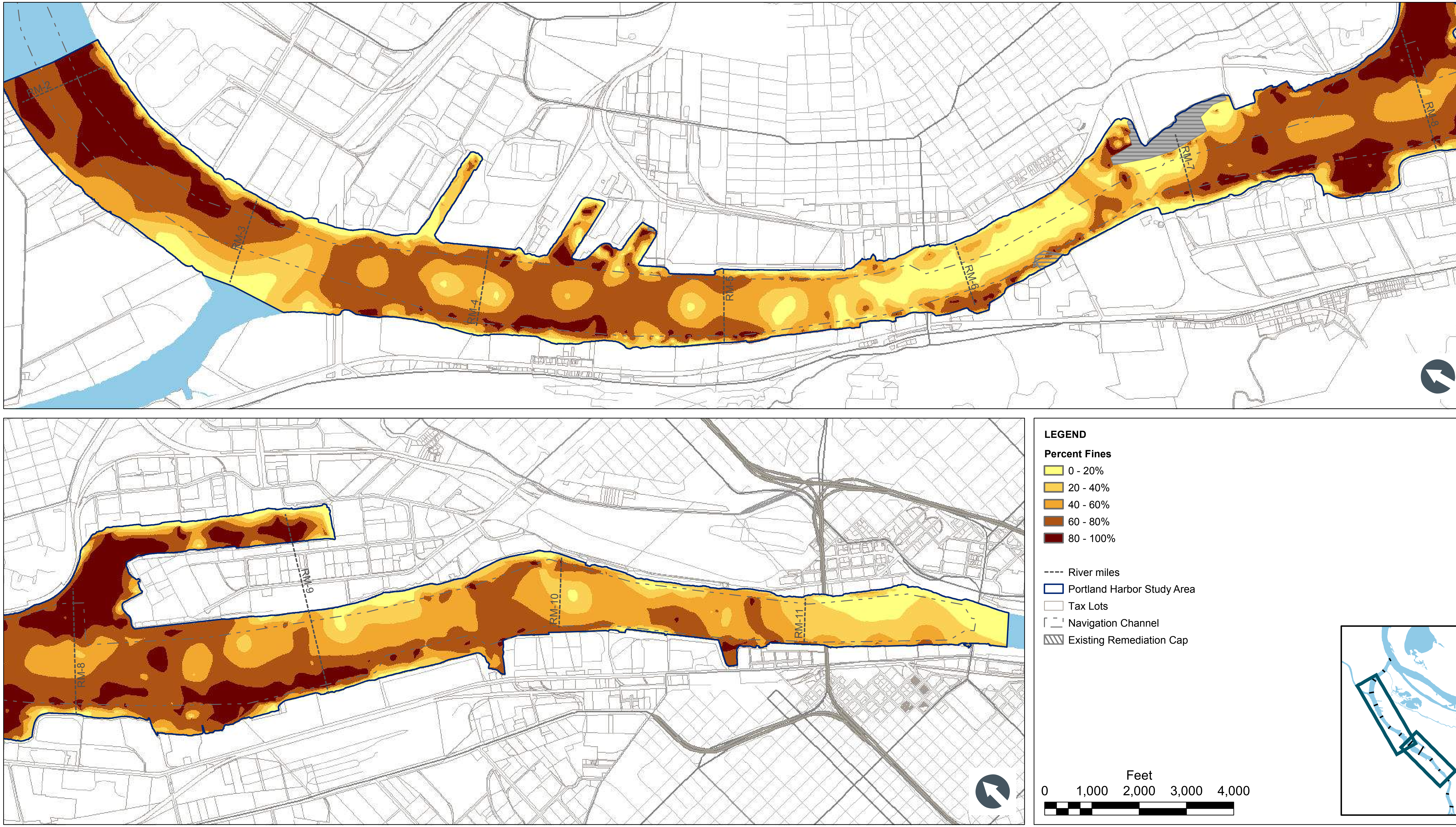

Figure 4-4 Existing Substrate Conditions

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